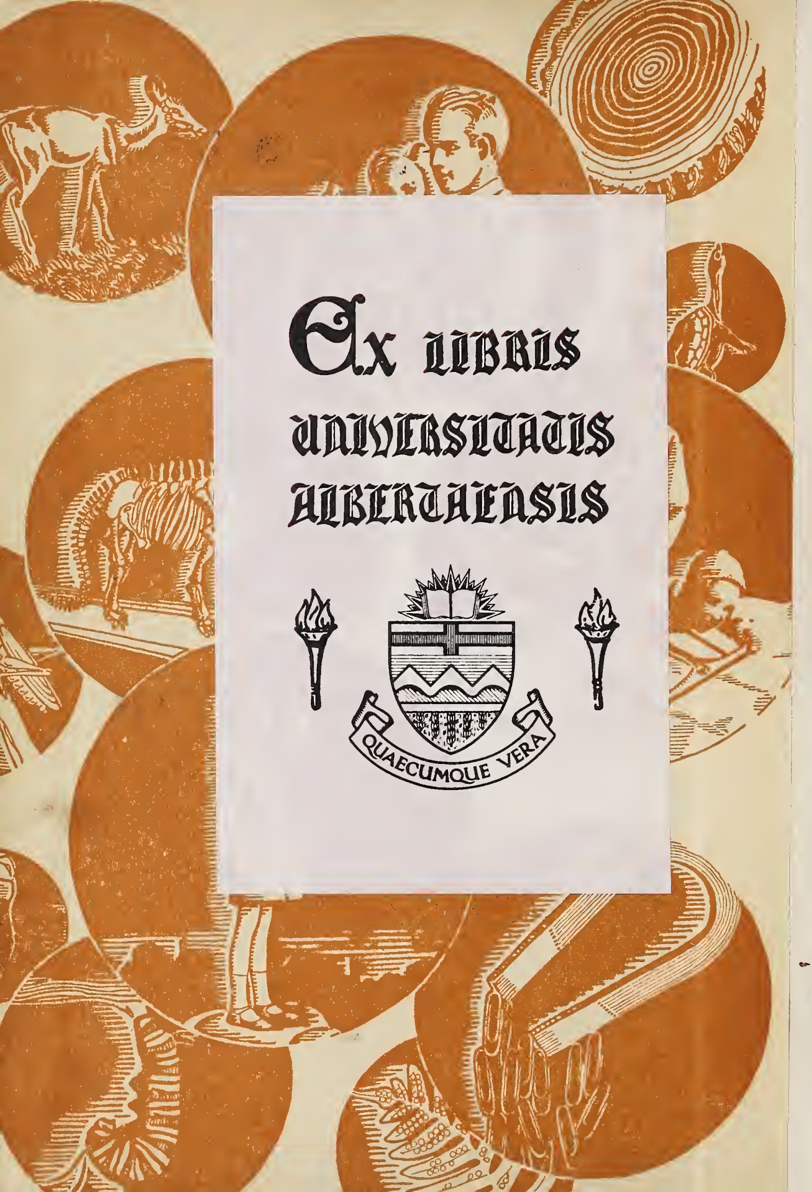
DISCOVERING OUR WORLD

A COURSE IN SCIENCE FOR THE MIDDLE GRADES

BOOK ONE



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Basic Studies in Science

DISCOVERING OUR WORLD

A Course in Science for the Middle Grades

by

WILBUR L. BEAUCHAMP
MARY MELROSE GLENN O. BLOUGH

• BOOK ONE •

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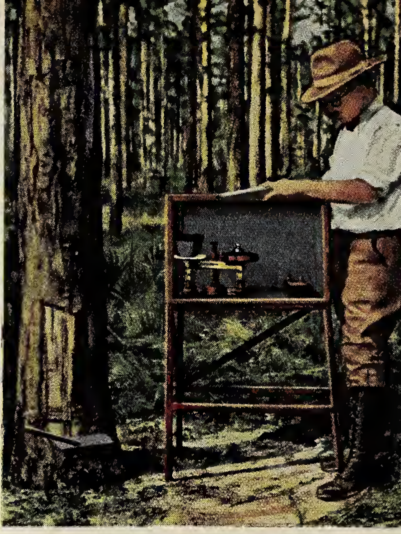
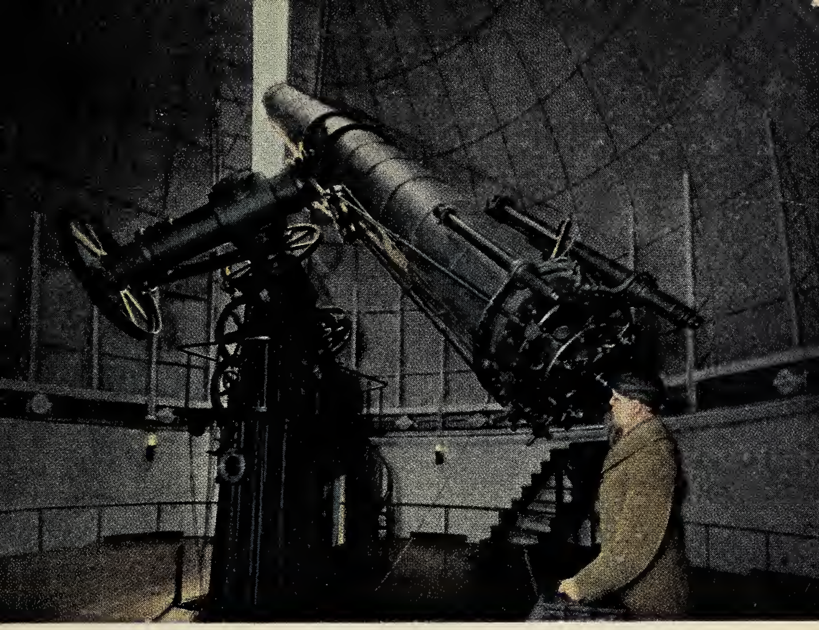


HOW DO WE DISCOVER OUR WORLD?

The men in these pictures are *scientists*. Scientists are men and women who study the things on the earth and inside the earth. They are really *discovering* our world because they are always finding out new things about it.

The scientist in the first picture is trying to discover how to make a new kind of paint that will not crack or wear off easily. He is using *materials* he has taken from rock and from the inside of trees and of other plants.

The scientist in the second picture is *examining* some of the plants that live on the earth. He is studying the trees to find out how they grow. Then he will try out different things to discover how he



can make the trees grow faster and stronger. We say that these two scientists are *experimenting*. This means that they are trying out different things to see how they work.

In the picture on this page is a scientist who is studying things beyond the earth. He is using a giant *telescope*. He is *observing* the moon. This means that he is *looking* at the moon carefully and thoughtfully to find out things about it.

Scientists like this man have found out what the moon is made of, and they know what makes the man in the moon! They even know how fast the

moon is moving! They know how far away the stars are, and they know what stars are made of. They have found out all of these things by experimenting and observing very carefully.

This boy and girl in the picture on this page are using a *microscope* to discover things about the earth on which they live. They are finding out many things. They are experimenting, discovering, examining, observing, in just the same way in which scientists do. They are going to find answers to questions like these:

How is a butterfly different from a frog?

What does a tree need so that it can grow tall and strong?

What happens to a piece of bread when you swallow it?

Where does the sun go at night?

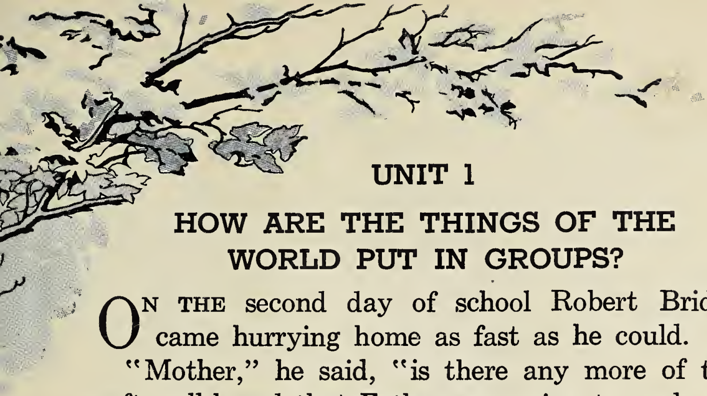
Why does winter come?

What makes a train move?

As you study this book you will learn the answers to these problems. Are there some other questions that you would like to ask? Make a list of them and see how many of them you can answer as you study your book.

As you study this book, you will find some new words that scientists use. You will want to know what they mean, so that you can use them, too. In the back of your book is a list of these words. The list tells you how to pronounce or say the words. It also tells you what the words mean. Turn to page 269 now and examine the list, so that you can see how it will help you.

After you have studied part of the book, you may want to find something in the part you have read. Turn now to the index on page 275. Read the page that tells you how to use the index.



UNIT 1

HOW ARE THE THINGS OF THE WORLD PUT IN GROUPS?

On the second day of school Robert Bridges came hurrying home as fast as he could.

"Mother," he said, "is there any more of that soft wall-board that Father was using to make the new room?"

"Yes," answered his mother, "there are some small pieces left, I'm sure. Why? What do you want them for?"

"I want to fix up my butterflies so that I can take them to school tomorrow. Those soft boards will be just the thing. I can pin the butterflies to them easily. Miss Burt wants us to bring anything we've collected outdoors. She said to bring pet animals, too, and some plants."

So Robert went to work with his butterflies. He found some cardboard boxes to put the boards in and sawed the wall-board to fit inside them. Then he pinned the butterflies to the boards and put them in the boxes.

Next morning Robert's mother helped him tie his boxes of butterflies together so that he could carry them safely, and soon he was on his way to school.

When he came into the school-room, the others in the class crowded around to see what he had. Miss Burt came to look at Robert's butterflies, too.

"You had better put them on the shelf, Robert," she said. "Everyone can see them easily there. The rest of you may put your things there, too."

This shelf was about two feet wide and just high enough for the boys and girls to see everything that was on it.

While the children were looking at Robert's butterflies, they asked him one question after another about them. He was glad he could answer so many of the questions. At last John asked, "How did you learn so much about butterflies?"

"By watching them," answered Robert, "and by reading about butterflies in a book I got from the library."

"Robert has told us two of the best ways of learning about the things around us," said Miss Burt. "Watch things closely, and read about them.

"You will find many things that you will not understand. You will want to ask questions about them. I'll help you find answers to your questions, and books will answer questions for you, too. But you will want to find answers by yourself whenever you can. Your eyes, your ears, your fingers, and even your noses will help you find the answers to questions if you use them well."

Here are some of the things that the children in one class had on their shelf. One boy had a pet porcupine!

The next day more of the boys and girls came with things for the science shelf. Grasshoppers, a stuffed squirrel, stones, colored glass, snakes, and plants were some of the things they brought.

What are the two big groups of things?

"If you put these things in some order, it will be much easier to learn about them," said Miss Burt. "We have the snakes next to the stones, the butterflies next to the white rats, and the grasshoppers beside the stuffed squirrel. I think we should put them in some kind of order."

"I know what you mean," said John. "My father keeps different sizes of nails in different boxes, and he has other boxes with a different kind of thing in each box. I know just where to look when I want to find anything."

"That's good, John," answered Miss Burt, "but what should we do to put our shelf in order?"

For a while no one could think what to do. Then Nancy almost shouted, "Oh, I know. Let's put the things together that are like each other."

"That is a good plan," Miss Burt answered quickly. "It is the way a scientist would start. He would separate all of these things into different groups. Let's do that, and let's find out why some of these things belong together and some do not. It will take us several weeks.

"Now, how shall we start to separate our collection into groups of things that belong together?"

"Well," replied Nancy, "the rocks and glass don't belong with my cat and kitten. The cat and kitten are alive, but rocks and glass are not alive."

"Good," said Miss Burt. "All the things in the world may be divided into two groups—*living* things and *non-living* things. When we say *non-living*, we mean something that never was alive."

* * *

What are two good ways of learning about the world we live in?

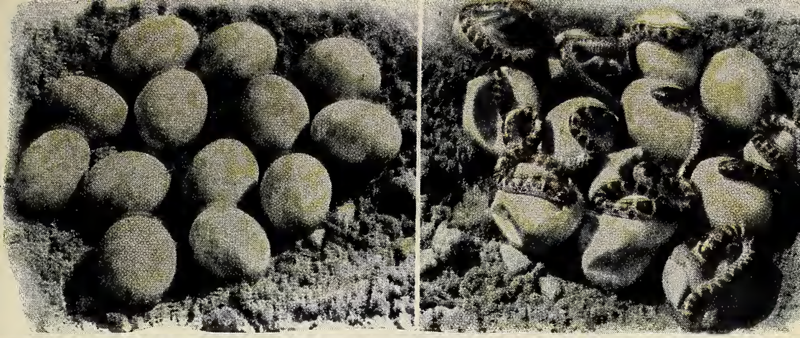
How can your eyes, ears, fingers, and nose answer questions for you?

Did the children bring things to school—

a) to make the room look better, or

b) to play with them, or

c) to learn about them?



These baby snakes came from eggs laid by a mother snake.

How are living things alike?

Then the boys and girls started thinking and talking about how living things are alike. As they talked, Miss Burt wrote on the blackboard what they said about living things.

Living things
1. can move
2. can breathe.
3. need food.
4. can grow.
5. can make others like themselves.

When Miss Burt had finished writing, she said, "Suppose you place all of the living things at one end of the science shelf. At the other end put the non-living things."

"My cat and kitten are certainly living things," Nancy said. "I know they are alive because they eat. I give the cat three dishes of milk every day, and Kitty has grown much larger. Cats can move, and they can make others like themselves, too, for the cat is the mother of the kitten."

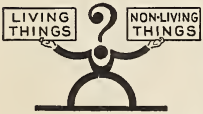
Kirk Fisher picked up one of the stones in his collection. Of course it was a non-living thing. It did not eat food, drink water, or breathe air. It would never grow into a big rock. It could not make a little rock like itself, and it could not move itself.

"A piece of glass does not have any eyes or ears, and it has no nose or mouth," said Peggy. "Non-living things can't see, hear, smell, feel, or eat."

Henry said that you could leave a stone by the side of a tree for years. The tree would grow larger, but the stone would not get bigger. Helen was certain her plant was alive because she had seen it grow bigger.

At last the class had all of their things placed in two groups. They made one cardboard sign that said LIVING THINGS and put it at the end of the shelf where all the living things were. Another sign said NON-LIVING THINGS. This was put up in front of the non-living group.

* * *



Tell five ways in which living things are different from non-living things.

What does *non-living* mean?

Separate these ten things into two groups.

Nail	Boy	Stone	Apple-tree	Penny
Bird	Dog	Bottle	Hammer	Grasshopper

How can we divide living things into two groups?

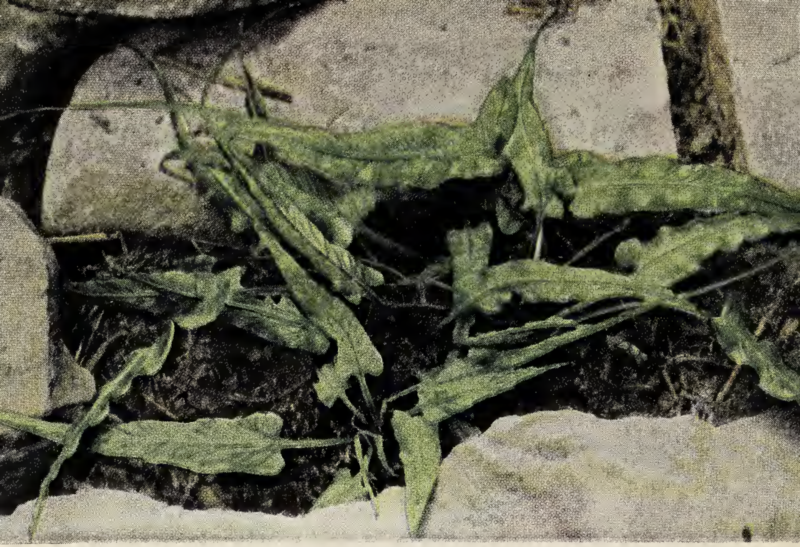
Betty now looked at the two groups and said, "It didn't take long to get everything put in order, did it?"

"Oh, but we have just started," Miss Burt said. "We have only the two large groups into which everything in the world may be divided. A scientist says that everything belongs either to the living world or to the non-living world. But a scientist wants to know more than that. He must know the different kinds of things in each group.

"Now," Miss Burt went on, "we can separate all living things into two big groups. Will all of you look at the living things on the shelf? See if you can find for yourself what the two groups are."

"Well, my white rats and Helen's geranium plant don't belong together," said Charley Adams. "I think the two groups are plants and animals."

"You are right," said Miss Burt. And the class went to work dividing their living things into the two groups. Of course they had no trouble telling a plant from an animal. But Charley had been thinking about plants, and he was beginning to wonder. He had learned that every living thing can move and that every living thing breathes. He knew that plants are living things, but he could not see that they really move and breathe.



This plant is called a "walking" fern because of the way it spreads itself over the ground. When the tip of a leaf touches the ground, roots grow from the tip into the ground, and a new plant grows up.

Perhaps you are like Charley Adams and think that plants do not move and breathe. Of course plants have no legs or wings with which they can move about from place to place.

But if you could see a motion picture of plants growing, you would be surprised. You would see stems shooting up and out, buds swelling, and flowers opening. Then you would know that the plants themselves are moving as they are growing. A tree grows so tall that it is higher than a house.

A little ivy plant may spread out until it covers the whole side of a big building.

Plants are living things just as much as animals are. They do most of the things that animals do. They grow. They take in air. They use food. They make other plants like themselves. You will learn about these things in your science work.

While the boys and girls were separating the plants and animals, Nancy began to be puzzled about something.

"We are certainly alive," she said. "So we must be either plants or animals. I know I am not a plant. Am I an animal, Miss Burt?"

"Yes, Nancy," answered Miss Burt, "you are an animal, and so am I. You and I are living things. So we must be either plants or animals."

The children laughed and said they did not know before that they were animals. Soon they had all of the plants and animals on the shelf divided into two groups. They made two more signs. One sign read PLANTS, and the other sign read ANIMALS. They put each sign with the group to which it belonged.

* * *

Can you name any living thing that is not a plant and is not an animal? Explain your answer.

Tell five things that living things can do.

How can we tell in what group a living thing belongs?

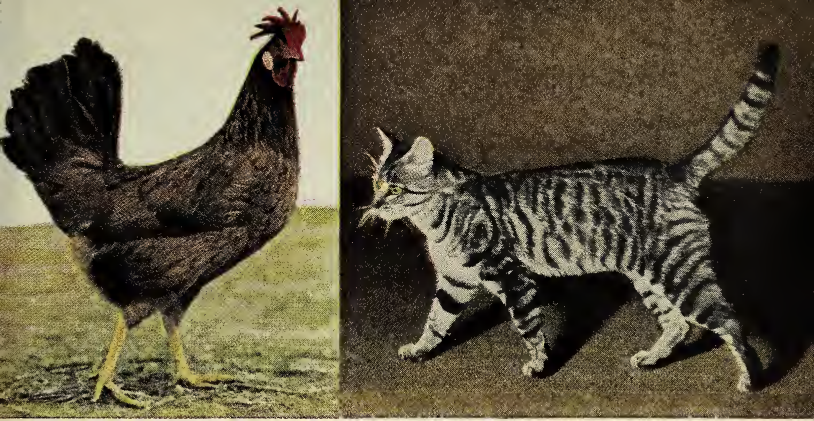
When the class came in one morning, Miss Burt said, "Our next problem is to divide our plants into different groups and our animals into different groups. That is what a scientist would do. A scientist studies things to see how they are made. He says, 'If they are made alike, they belong together. If they are made differently, they do not belong together.' How shall we begin?"

"Well, my snakes certainly don't belong with Charley's white rats," said Henry.

"That's easy to see," said Kirk Fisher. "The rats have hair, and they walk on legs. The snakes have no hair on them, and they slide along on their stomachs. They aren't made like rats."

Then the boys and girls began to talk about all the differences they could find in the way animals are made. They thought of two-legged animals, four-legged animals, and even eight-legged animals. They named animals that have no legs, some that have fins, and some with wings. They had seen animals covered with hair, animals covered with scales, and animals with smooth skin like a frog's.

Miss Burt told the class that scientists have a word that they use when they talk about the way anything is made. The word is *structure.* The structure of an animal tells you what parts it has.



"Let's see," she said, "how many differences we can find between the structure of a chicken and the structure of a cat." Here is the list the class made:

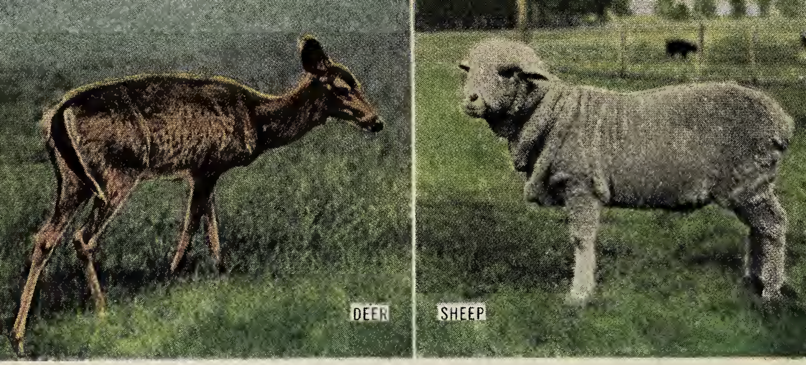
A Cat's Structure	*A Chicken's Structure*
1. Four legs	1. Two legs
2. No wings	2. Two wings
3. Hair	3. Feathers
4. Mouth and lips	4. A bill
5. Teeth	5. No teeth
6. A nose	6. Holes in bill for nose
7. Ears that stick out	7. Holes in head for ears

After the children had studied the two lists, they could easily see what *structure* means.

* * *

Tell five things about the structure of a dog.

How are horses and dogs alike? How are they different?



To what group do these animals belong? How do you know?

What is a mammal?

"We have a good collection of animals here on our science shelf," said Miss Burt one morning. "And they belong to many different groups. There are birds, fish, insects, reptiles, mammals, and amphibians."

The children were puzzled at what she said, for they did not understand some of these words.

"I thought a mammal was a wild animal that would hurt you," Billy said.

"Billy," said Miss Burt, "are you afraid of your pet rabbit and of this cat and its kitten?"

"Of course not," answered Billy.

"Well," said Miss Burt with a smile, "they are mammals. Let's learn about mammals first. Look at the cat, the white rats, and the rabbit. They are mammals. What can you find out about their structures? How are they alike?"

John Cole was the first one to answer. "Well," he said, "every one of these animals has four legs and two eyes."

"That's good, John," answered Miss Burt, "but so does the frog. And the frog is not a mammal. You will learn later what group the frog belongs in. Is there any other way the cat, the rabbit, and the rats are alike?"

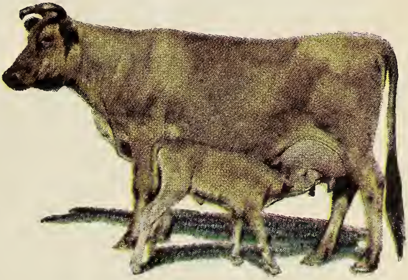
Quickly Mary spoke up. "They are all covered with fur," she said.

"Yes, of course," said Miss Burt. "All mammals are covered with fur or hair, or else they have hair somewhere on their bodies."

Just then Peggy said, "Oh, look at the cunning little kitten getting its dinner!"

Peggy had found another way in which mammals are alike. They feed their babies milk from their own bodies. The mammal is the only kind of animal that does this. All baby mammals are raised on milk.

These are the two ways in which mammals are different from all other animals. They have fur, or hair, and they feed milk to their babies.



This cow, like all mammals, gives milk to her baby.

Then Miss Burt told the class another very important thing about mammals. She said that mammals are *warm-blooded.*

Do you know what warm-blooded means? Perhaps your mother has put a thermometer under your tongue when you were sick. She wanted to find out whether your body was too hot or too cold. The body of a mammal stays at almost the same temperature all the time, unless the animal is sick. If the body is warm, then the blood must be warm, too.

The children learned these things about mammals:

1. Mammals have fur, or hair.
2. The mothers feed the babies milk from their own bodies.
3. Mammals are warm-blooded.

Miss Burt then asked the boys and girls to look carefully to see if they could find other mammals in the room besides the rabbit, the rats, and the cat.

The children looked and looked. At last Robert said, "I know. We are mammals." Robert was right. We have hair; our mothers feed their babies milk from their own bodies; and we are warm-blooded.

Which of these animals are mammals?

dog horse frog cow snake crow beaver lion

There are many kinds of birds in the world, but they all have feathers, two wings, and two legs.

How are birds different from other animals?

Finding the important things about the structure of birds was easy for the boys and girls. Of course they had all seen many birds. They could look out of the school-room window and see bluejays, sparrows, and robins. Every bird they could think of had two wings, two legs, and feathers. They decided that all birds have this kind of structure.

"I think birds are warm-blooded, too," said Mary. "I had a little baby chick once, and it felt warm when I held it in my hands."

"One day I caught a duck out on my grandfather's farm," said Henry. "He tried to get away, and I had to dig my fingers down through his feathers to hold him. His body was warm, and it was a cold day, too."

"You are both right," said Miss Burt. "Birds are warm-blooded. And there is another important thing about their structure. What is the difference between the inside of a dog's mouth and the inside of a bird's mouth?"

"When we looked at the chicken," said Peggy, "we saw that it didn't have any teeth. And I'm sure my canary has no teeth."

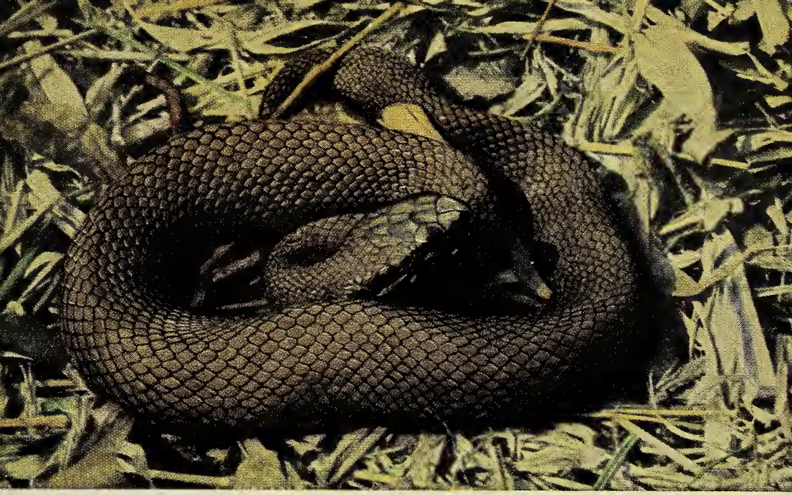
"That is true, Peggy," said Miss Burt. "Your canary has no teeth. Birds do not have teeth."

The class was now ready to write on the board the important things about the structure of birds.

1. Birds are covered with feathers.
2. Birds have two wings and two legs.
3. Birds do not have teeth.
4. Birds are warm-blooded.

* * *

How are birds like mammals? How are they different from mammals?



Can you see the scales on the snake?

How are all reptiles alike?

"We have learned what mammals are, and we have studied birds," said Miss Burt.

"What animals shall we study next?"

"I'd like to know about my snakes," said Henry. "Where do they belong?"

"You caught the snakes, Henry," replied Miss Burt, "and you have had plenty of chance to study them. A snake is a reptile. What can you tell us about the structure of reptiles?"

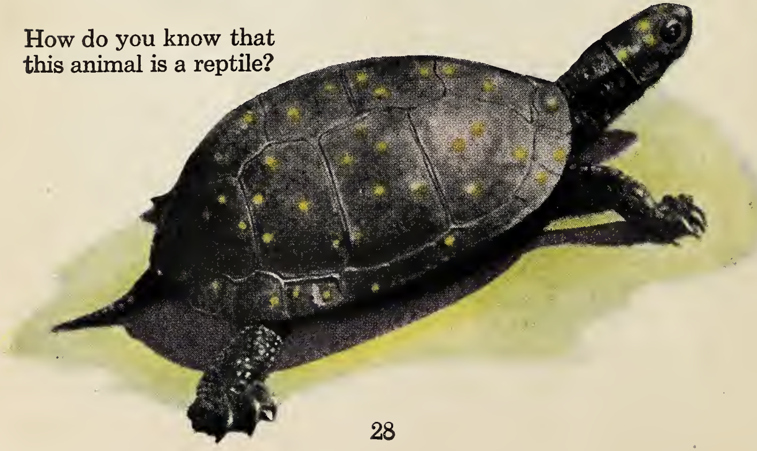
"Well," said Henry slowly, "they haven't any legs or wings, and they are not covered with feathers or hair."

"Let's look closely at your snakes," said Miss Burt, "to find what they are covered with."

So the boys and girls crowded around the box while Henry took out one of his snakes. As they looked at it carefully, Peggy suddenly said, "Why, it is covered all over with little scales!"

Then Miss Burt went to her desk. "Here's a big snake skin that my uncle sent me," she said. "You can see the scales easily on this."

On this skin the boys and girls could plainly see the thin, flat scales. They seemed to fit over each other like shingles on a roof. The class was just about ready to decide that all reptiles have scales like the scales on a snake. But Miss Burt said, "Let's look at another reptile." She went over to the turtles in the pan of water. "Are there any scales on this animal?" she asked, as she took one of the turtles out of the water and gave it to Billy.


How do you know that
this animal is a reptile?

"Why! Is this a reptile?" asked Billy. "It has four legs."

"Yes," replied Miss Burt, "the turtle is a reptile. Reptiles have either very short legs, or no legs at all."

"Well," said Billy, "I don't see any scales, but it has a hard shell."

When the boys and girls studied the shell, they were surprised to find that it was made of plate-like scales. The scales fitted together so closely that they seemed to make one hard piece.

Then Miss Burt explained that sometimes the covering of a reptile is made of separate scales, and sometimes it is made of scales or plates that fit together in one piece, like a turtle shell. Turtles have scales on their legs and neck. Alligators, crocodiles, lizards, snakes, and turtles are all reptiles, she told them.

"I don't think reptiles are warm-blooded," said Henry. "Every time I catch a snake, it feels cold to me."

"You are right, Henry," answered Miss Burt. "Snakes are not warm-blooded animals. They are cold-blooded."

Then she explained that *cold-blooded* really means that the blood changes temperature. When a snake is sunning itself on a rock, its blood is warm. But when the snake is in a cold hole in the ground, its blood is cold. All reptiles are cold-blooded.

Now the class was ready to write on the board the important facts about the structure of reptiles.

1. Reptiles are covered with scales or plates.
2. Reptiles are cold-blooded.
3. Some reptiles have legs; some have no legs.

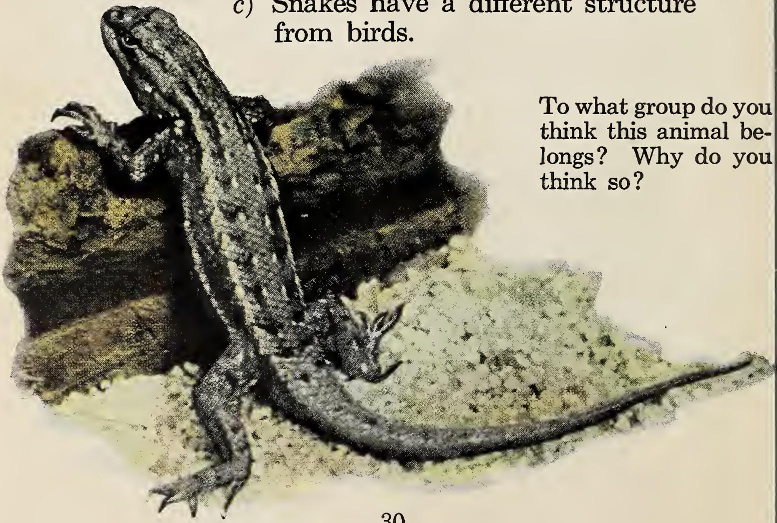
* * *

Tell one way in which reptiles are different from birds and mammals.

Why are some animals called cold-blooded and other animals called warm-blooded?

Which sentences below are right?

a) Snakes have scales.
b) All reptiles have legs.
c) Snakes have a different structure from birds.



To what group do you think this animal belongs? Why do you think so?

How are fish alike?

Kirk Fisher had been on a fishing trip with his father just before school opened. He had seen many kinds of fish—perch, bass, and sunfish. He had helped catch them, clean them, and eat them. So he had learned many things about them.

"I don't see why fish aren't reptiles," he said. "They are covered with scales, and I think they must be cold-blooded."

"You are partly right," said Miss Burt. "All fish are cold-blooded, and nearly all of them are covered with scales. But fish are not reptiles. Let's look at these goldfish. What can you see on the fish that you can't see on a snake?"

Peggy was quick to answer, "Fins."

"Yes," said Miss Burt. "Fish have fins. Is there anything else you can see?"

"I know," said Kirk. "Fish have gills. I kept my fish on a string that I put through their gills and out through their mouths. And why do fish make their gills go in and out all the time, as goldfish do?"

"Fish breathe through their gills," explained Miss Burt. "Your chest goes up and down when you breathe. The covering of a fish's gills goes in and out every time the fish breathes. Living things have to breathe, and fish breathe with their gills."

* * *

Tell three facts about the structure of fish.

Tell one way in which fish and reptiles are alike.

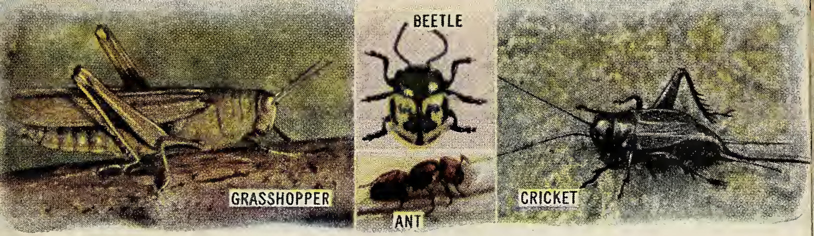
What is the structure of insects?

"Well," said Robert, "it seems to me we have all the animals in groups except my butterflies, the grasshoppers and crickets, John's ants, and the frog. I'd like to know about my butterflies."

"Very well," answered Miss Burt, "and we shall learn about the grasshoppers, the ants, and the crickets at the same time. They belong together in a group called *insects*. You may not think that they belong together, but when you study their structure, you will see why they do.

"There are enough of these animals in the cages and jars so that each of you may study one," said Miss Burt. "Take a grasshopper, a cricket, a butterfly, or an ant. Either a dead one or a live one will do. If you put some of the live ones in these small glass jars, you can watch them move.

"Then, you may work together in groups. All who want to look at a grasshopper will be in one



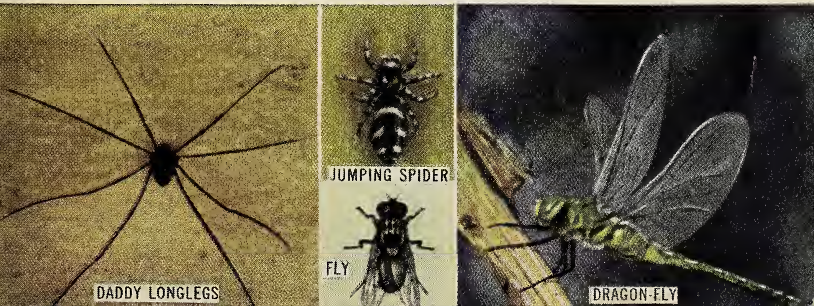
Can you answer the questions on this page by studying the animals in this picture?

group, and those who want to study ants will be in another group. Try to find the answers to these questions on the blackboard."

1. How many legs does the animal have?
2. How many parts are there to its body?
3. What is it covered with?
4. How many feelers does it have?

At last the boys and girls were ready to tell what they had found. Betty told about the grasshoppers. She said, "Grasshoppers have six legs. When we looked on the underside of the grasshopper, we could see three parts to its body. It seems to have some kind of hard covering over its body. There are two feelers that stick out from its head."

Look at the picture below and see if all the animals in it are insects. How can you tell?



Then John told about his ants. "An ant," he said, "has six legs, too. And you can easily see three parts to its body. It also has a hard covering, and there are two feelers on its head."

The structure of these six-legged animals that the class had been studying is quite different from the structure of the other animals in this book. The body of an insect is divided into three parts. The legs and wings are fastened to the middle part of the body. Sometimes an insect has two wings and sometimes four. Sometimes, though, it has no wings.

Perhaps one of the most interesting things about insects is that they have no bones. Mammals, birds, reptiles, and fish have a framework of bones on the inside of their bodies. This framework is called a *skeleton*. The skeleton helps to hold the soft parts of the body together.

Insects have a hard covering on the outside of their bodies. This covering takes the place of the bony framework. On some insects the covering is almost as hard as your finger-nail. On others it is very thin. The parts of the insect's body are fastened to this covering. So we say that the insect's skeleton is on the outside of its body.

Henry had been holding a grasshopper under a magnifying-glass. "Miss Burt," he said, "what is this little row of dots along the side of the grasshopper?"

"Those little dots are air holes," said Miss Burt. "The grasshopper breathes through them. Insects breathe through air holes. We keep our chests going up and down to breathe, and the fish keeps its gill covering going in and out. But insects breathe through the many holes in their bodies."

* * *

Name five ways that all insects are alike.

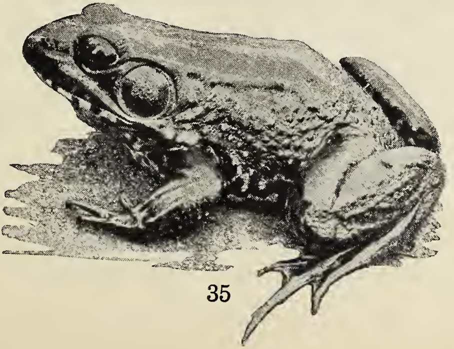
How do insects breathe?

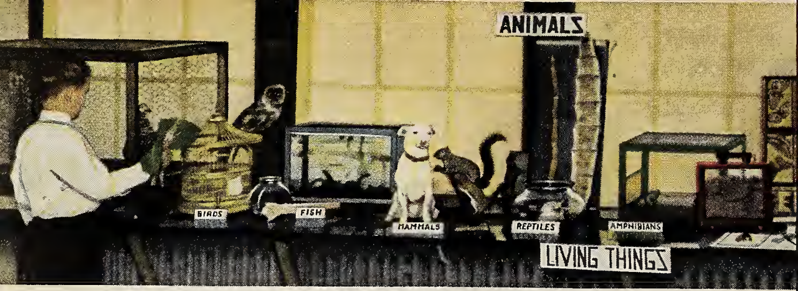
How many of these ways did the boys and girls use to find the answers to their questions?

Thinking Reading Asking Watching

What is an amphibian?

"We have now come to the last group of animals on our science shelf," said Miss Burt one morning. "We have studied everything except the frog. Suppose you examine the frog and find out for yourselves all you can about its structure. First of all, I'll tell you that the frog belongs to the group





of animals called *amphibians.* The word means that the animal lives both on land and in water.

The class studied the frog carefully. Finally John said, "We've decided that the frog is different from the other animals in our collection because it has no covering except skin. It feels cold, too; so we think it is cold-blooded."

"You have done very well," replied Miss Burt. "Amphibians have no hair, no feathers, and no scales or plates. They are cold-blooded. But there is something very important about amphibians that you could not find out by looking at the frog. Amphibians are hatched in water and live there while they are growing up. Even after they grow up, many of them can live in water as well as they can live on land. Toads are amphibians, too."

A few days later Billy came to school much excited. "Come and see what I have!" he called. The boys and girls gathered close to see, but not one of them could tell what kind of animal was in the box.

They asked Miss Burt to tell them what it was. But she only said, "Examine its structure, and perhaps you can find to what group it belongs."

When the boys and girls looked at this new animal, they saw that its body was not covered with fur or hair or feathers or scales. They said that they thought it was an amphibian.

The girls looked through a book that told about amphibians. They quickly found the picture of Billy's animal and learned that it was a salamander.

John said, "I can understand now why scientists learn about the structures of animals. Just see how easily we found out about the salamander."

At last the class had all the animals arranged in groups. They made a sign for each group:

MAMMALS BIRDS REPTILES
FISH INSECTS AMPHIBIANS

Miss Burt told the class that there were other groups of animals, but that the ones in their room were the most common groups.

* * *

What does *amphibian* mean?
How are amphibians like fish and reptiles?

How are plants divided into groups?

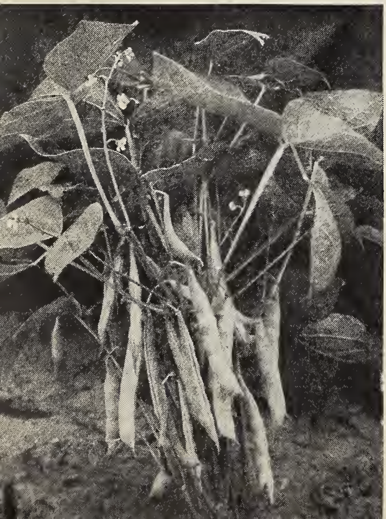
One day Miss Burt told the class that the next thing to do was to put the plants in groups.

"How will we do that?" Betty asked.

"We examined the structure of each animal to learn what group it belonged in," Miss Burt explained. "Now we must do the same thing with the plants."

"Do plants have a structure, too?" Robert asked, a little surprised.

"Of course you know that plants are not covered with feathers or fur and they do not have arms or legs or wings or eyes," Miss Burt answered. "But they do have parts, just as animals have parts. Structure, you know, means how anything is made. Let us study a plant to see how it is made."



She then showed the class a snapdragon plant she had pulled up from her garden that morning.

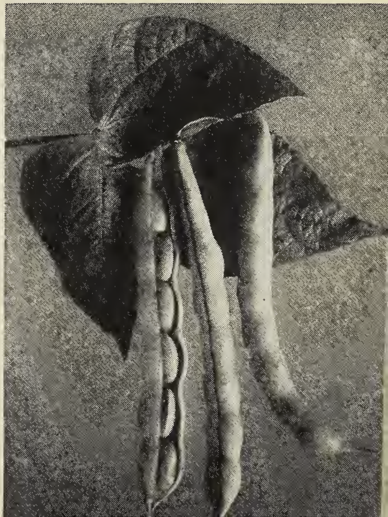
The children quickly pointed out some of its parts. They knew the *roots*, the *stem*, the *leaves*, and the *flowers*. Which of these parts can you find in the picture of the bean plant?

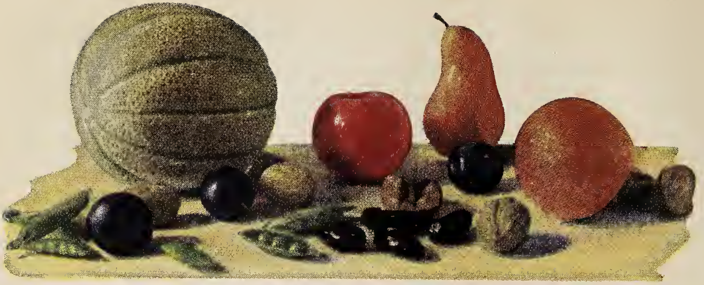
But there was one part of the plant that the boys and girls were not sure about. It was brown, and seemed to be some kind of pod. Mary was sure it had come from a flower. It grew on the plant in the same way that the flowers did. The class opened the pod to see what was inside, and there they found some seeds.

Then Miss Burt explained that every kind of plant that has flowers also has seeds. The flowers make the seeds for new plants. The flowers wither away, and the seeds are left to fall to the ground and grow into new plants.

"This afternoon when you get home," Miss Burt said, "look for some flowers that have gone to seed and bring them to school."

The next day John brought a sunflower that had many seeds in it. Billy brought a bean plant from his father's garden. As he showed it to the class, he said, "You can see the roots, the stem, the leaves, and a flower. The seeds are the beans inside the bean pod. And here is a tiny bean pod that is just starting to grow from the flower."





Here are some parts of different plants in which the seeds of the plant are found. How many of these can you name? Do the plants from which they came have flowers? How do you know?

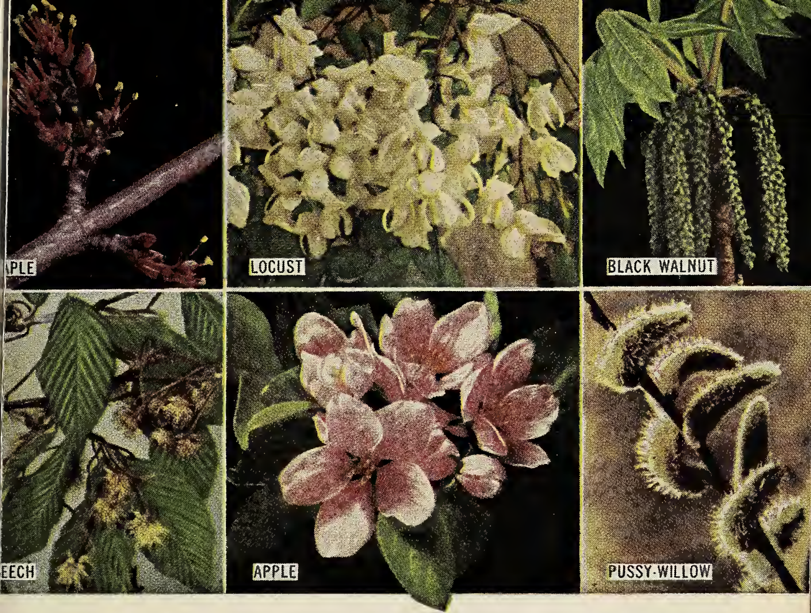
"Do all plants have seeds?" Henry asked.

"No, Henry," Miss Burt answered. "And because some plants do not have seeds, we can divide the plants on the shelf into two groups. These two groups are: plants that have seeds, and plants that do not have seeds.

"Now," said Miss Burt, "how many kinds of plants that have seeds do you know?"

The boys and girls did not have any trouble naming seed plants. They named sweet peas, daisies, asters, pansies, and many others that their mothers planted in their gardens.

"Acorns must be seeds," said Billy. "I pulled up a tiny oak tree, and it had an old acorn sticking to the roots. But I have never seen any flowers growing on an oak tree."



Which of the flowers in this picture have you seen?

"Acorns are seeds, Billy," said Miss Burt. "And oak trees have flowers, too. Perhaps you think that flowers are always white or red or yellow or some other bright color. But when a scientist uses the word *flower*, he means the part of the plant that grows seeds.

"Maple trees have flowers. So do beech, hickory, and walnut trees. Their flowers are small, and you probably have never noticed them. You eat the seeds of some of these trees, but you call them nuts."

"You certainly can see the flowers on apple trees and horse-chestnut trees and locust trees," said Nancy. "And smell them, too."

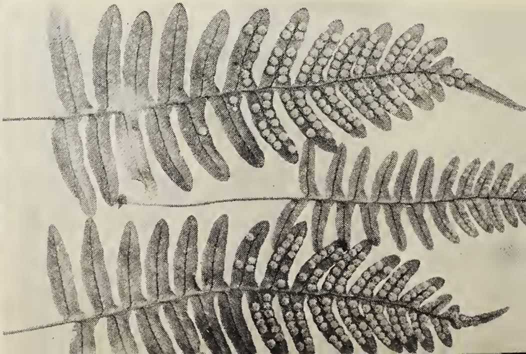
"Grass must have flowers, too," said Henry. "We planted grass seed in our yard this spring."

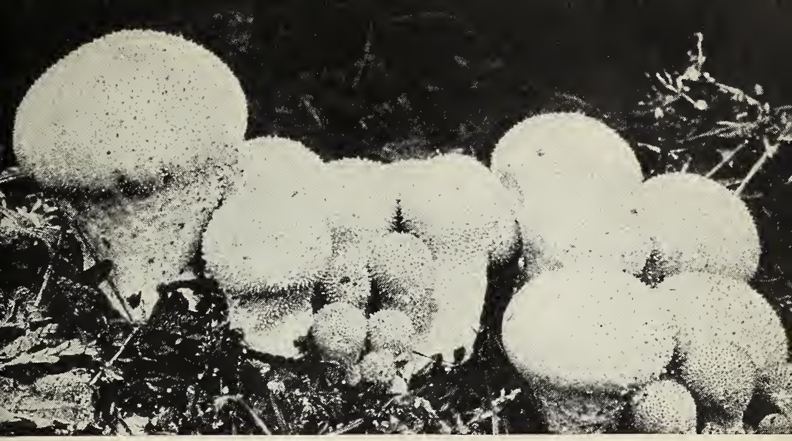
"Yes," replied Miss Burt, "grass has flowers, too. Corn tassels are really flowers, and the tops of wheat plants have tiny flowers in them.

"Do you see that we are dividing plants into groups in the same way that we divided animals? We group plants according to the way they are made. All the plants that have flowers and seeds are put in the same group.

"Now let us learn about plants that have no flowers and no seeds," said Miss Burt. "First, let's look at Betty's fern. Did you ever see flowers on a fern? I'm sure you never did, for a fern does not have either flowers or seeds."

Then she showed the class the underside of a fern leaf. There were rows of little yellow-brown dots on it, just like the ones you see in the picture on this page.





How are these puff balls different from a geranium?

The dots fall off, Miss Burt explained, and after awhile fern plants grow from them. The children took some of the dots off the leaf and crushed them on a piece of paper. They looked just like brown dust. They were not at all like the apple seeds, bean seeds, and other seeds the children had seen.

"You can see more brown dust if you crush one of these puff balls," said Miss Burt.

"Oh! Look at the brown powder," said John, as he crushed a puff ball.

The boys and girls then examined some green moss. They saw many small plants growing very close together.

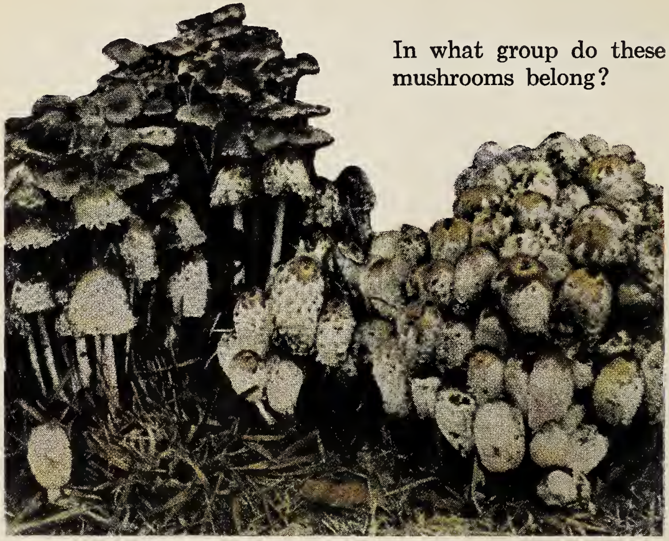
"These plants are so tiny that they don't seem really to have leaves and stems," Nancy said. "I'm sure moss doesn't have flowers or seeds."

"And this toadstool doesn't have any leaves or flowers or seeds," added Henry, after he had carefully looked at it.

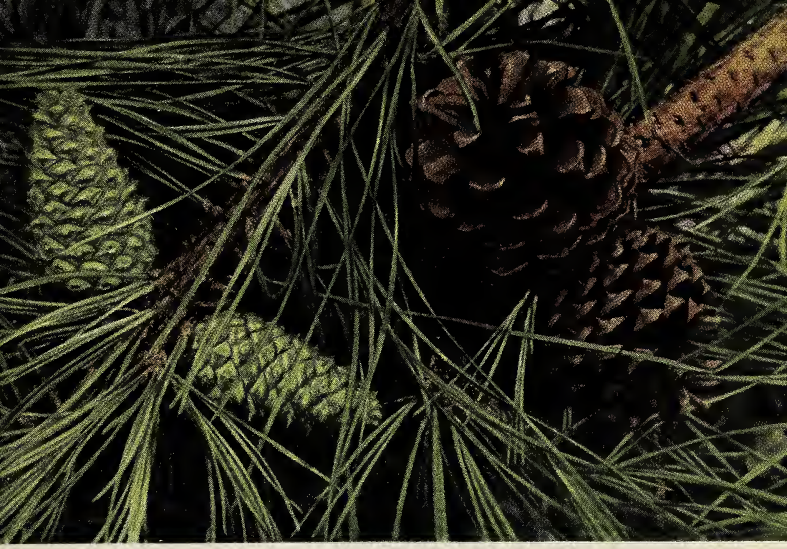
"That's right, Henry," Miss Burt said. "Toadstools, mushrooms, moss, and puff balls have no flowers or seeds."

Now the boys and girls were ready to put their plant collection into two groups on the science shelf. The boys made two signs:

PLANTS WITH SEEDS
PLANTS WITHOUT SEEDS



In what group do these mushrooms belong?



The green pine cones are still growing, and the seeds are growing inside them. The brown cones have opened, dried, and dropped their seeds to the ground.

They had very little trouble separating the plants until they came to the cone from a pine tree. They did not know whether pine trees grew from seeds or what the cone was for. While they were looking at the cone, some seeds fell out of it.

Miss Burt told them that this cone was the part of the pine tree that grew seeds. If they planted the seeds, little pine trees would grow.

She explained that all the plants with seeds are divided into two groups. One group grows its seeds in flowers. The other group grows its seeds in cones. The pine, the spruce, and the hemlock are trees that grow their seeds in cones.

* * *

Which phrases below tell you something about the structure of a plant?

Grows in the water
Has red flowers
Needs plenty of sunlight
Lives only one year
Has a short, thick root
Is good to eat
Has sharp thorns
Has big, thick leaves

What does the flower do for the plant?

Make a list of all the plants named in the pages you have just read, and divide them into two groups. Put the right name at the top of each group.

Questions to Think About

1. If you found an insect that had wings, would it be right for you to say that all insects have wings? Explain your answer.

2. If you found an animal in the woods and wanted to know what kind it was, how would you find out?

3. Which sentences tell something about structure?
   - *a*) My dog is very gentle.
   - *b*) Our cat never kills birds.
   - *c*) The plant had large, brown seeds.
   - *d*) Monkeys have long tails.
   - *e*) The bark of the tree is gray and smooth.
   - *f*) Horses eat oats and corn.
   - *g*) Children need plenty of sleep.

4. First separate these things into two groups, living and non-living. Then write the names of the plant and animal groups you have studied, and put each living thing in the group where it belongs.

Mouse
Hammer
Cricket
Toad
Geranium
Toadstool
Rock
Bottle
Moss
Snake
Sunfish
Penguin
Ant
Fox
Peach tree
Turkey
Sheep
Pencil
Duck
Grasshopper
Alligator
Salmon
Lizard
Frog
Pine tree
Dandelion
Yourself
Hemlock

Things to Find Out

1. Study the animals in a zoo and try to tell what group each animal belongs in.

2. Make a Picture Zoo. Gather all the pictures of animals that you can find and separate them into groups. Get a scrapbook and put the pictures in by groups.

3. Find two plants that you can bring to school. If you can do so, get plants that are very different from each other. Be ready to tell everything you can about the structure of each plant. Show how the plants are alike and how they are different.

UNIT 2

HOW DO LIVING THINGS GROW?

THE boys and girls in Miss Burt's class worked out a plan to take care of the plants and animals they had brought to school for the science shelf. Of course their grasshoppers and white rats and turtles and snakes and other animals had to have food to eat and water to drink. The plants had to be watered, too. The children were to take turns feeding and watering them.

What happens when living things grow?

One day while Billy was taking his turn, he suddenly cried out, "Come and look at this."

A group of boys and girls quickly gathered around the caterpillar cage. To their surprise, the skin of one caterpillar had split open, and the caterpillar was coming out of it! Slowly he crawled out of his old skin and stretched himself out on a leaf.

The children had watched one of the most interesting things that happen to a caterpillar while it is growing. Our skin grows larger and larger as we grow. The skin of the caterpillar does not grow. When the caterpillar gets so big that its skin is too tight, the old skin splits. Out comes a larger caterpillar with a new and larger skin.

The caterpillar has a strange way of growing. But other living things have strange ways of growing, too. You have seen growing things all your life. Have you ever watched them to see what happens while they are growing?

Did you ever find a tadpole in a pond in the spring? If you kept the tadpole where you could watch it grow, you know what happens. After many weeks the animal has changed from a wiggling tadpole in the water to a frog that hops about on land.

All the changes that the caterpillar and the frog go through are a part of their growing. They seem almost to change from one kind of animal into another. Some animals make surprising changes. Other animals just get bigger and bigger without changing very much. Birds and fish and reptiles just get larger and larger. They do not grow in the way that caterpillars and tadpoles grow.

All living things—plants as well as animals—change while they are growing. Acorns grow into oak trees, and a corn seed grows to be a plant two times as tall as you are.

A baby chick is covered with soft down and is no larger than your fist. But when it grows up, it will be covered with feathers, and it will have a red comb on top of its head. It will be many times as heavy, too.

Petunia plants are only a few inches tall when they are planted. But they may grow until they are more than a foot high. More leaves grow on them, and flowers grow on them, too.

Can you think of ways in which living things change as they grow? Almost all the boys and girls in the class had something to tell about growing things. They were beginning to look at things carefully and to think about them as they looked. Then Miss Burt wrote this question on the board, "What three very important things happen when living things grow?"

These are the things that the class told:

1. Living things get bigger when they grow.
2. Living things add new parts to themselves when they grow.
3. Some growing things change so much that they look like different kinds of living things.

* * *

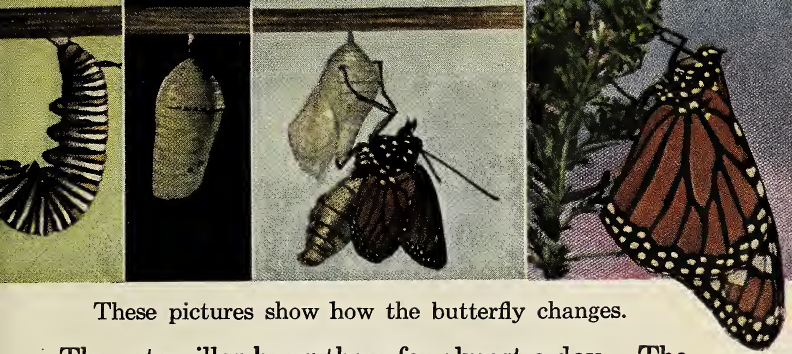
Read again the sentences numbered 1, 2, and 3 above. Then think of one or two changes in some growing thing to show what each sentence means. Try to think of things that are not told in your book.

How have you changed since you were two or three weeks old? Try to think of all the changes you can.

How do insects grow?

Of course, the class was keeping close watch of the caterpillar in the cage. Peggy had found the caterpillar on a milkweed plant. Milkweed was the only food this kind of caterpillar would eat.

For several days the caterpillar did almost nothing but eat. Peggy had to bring milkweed leaves every day. But one day it stopped eating and crawled up the side of the cage. Then it crawled along the underside of the board that covered the cage. It seemed to be looking for a hiding-place. At last it stopped and began to spin some silken threads that stuck tightly to the board. Then it fastened one end of its body to these silken threads and let the rest of its body hang down.



These pictures show how the butterfly changes.

The caterpillar hung there for almost a day. The class watched closely, but it was not until the next morning that they saw what had happened. To everyone's surprise, the caterpillar was gone. There, hanging from the board, was a beautiful green case with gold spots on it.

This case did not look at all like the black and yellow caterpillar. It did not even look alive. It was hard and almost like a shell. It was no longer a caterpillar. It was a *chrysalis*.

"Well, what's going to happen next?" asked Nancy, as she looked at the chrysalis. "Is this part of his growing? If it is, he certainly has much more trouble growing than we do."

"Wait and see," answered John.

For about two weeks the chrysalis hung there. Slowly it changed color and became dark brown. Then it began to get so light that the children could almost see through it. And at last they saw the most surprising change of all. The case began to split open, and out came a beautiful butterfly.

It all happened very slowly. At first the wings were wrinkled and folded together, and they looked moist as if they had been wet. After a while the butterfly began to stretch them out and to open and close them. The boys and girls could plainly see that the wings were drying and getting stiff. By the next morning the wings were full-sized, and the butterfly was flying about in the cage.

The butterfly does not grow larger. Soon after it comes out of its case, it is as large as it will ever be. Of course the boys and girls wanted to know the name of this butterfly. Its name is Monarch. Monarch means king, and this butterfly was so large and beautiful that the class thought the name was a very good one.

You have just learned how the Monarch butterfly grows. You have studied three parts of its life —the caterpillar, the chrysalis, and the butterfly. But where did the caterpillar come from?

If you examine the underside of the leaves of milkweed plants, you may find some little brown or green dots about the size of a pinhead. These dots are eggs, laid by a Monarch butterfly. The caterpillar that Peggy brought to school had hatched from an egg like these. Of course, it was only a tiny thing at first; but it ate and ate and grew and grew. It shed its skin two or three times before it made a chrysalis.

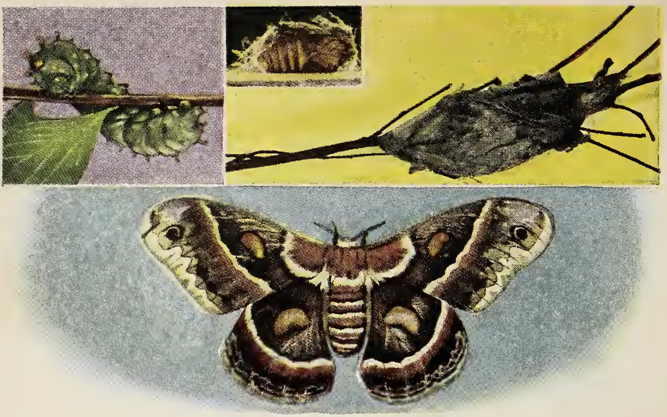
The skin on our bodies grows along with us, but the caterpillar's skin does not. It gets hard; so the caterpillar has to split the skin open when its body gets too big. A new skin grows to take the place of the old one. This shedding of the skin is called *molting.*

One morning Kirk Fisher brought a big caterpillar to class. It was almost four inches long, and was bluish green with knobs of different colors sticking out from it. Everyone was sure it would grow to be a very large butterfly. Kirk put it in the cage, so that the class could watch it.

One day Henry noticed the caterpillar doing something that the Monarch caterpillar had never done. It was moving its head around, and a silk thread was coming from its mouth. As the caterpillar moved its head, it threw the silk around its body. Soon it was covered with so much silk that it could not be seen. The caterpillar was making a *cocoon* for itself.

"Well," said Kirk, "he will be good and warm inside all that silk."

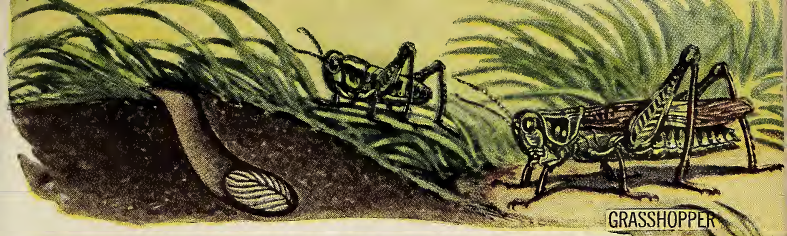
Kirk did not know why the caterpillar needed this warm house of silk. This kind of caterpillar takes all winter long to change. In the cocoon the living caterpillar slowly changes into the head, body, feelers, legs, and wings of an insect. But it is not a butterfly. It is a *moth.*



The picture on this page shows you what the moth looks like. It is called a Cecropia moth. It begins life as an egg, just the way the Monarch butterfly does, and it molts while it is a caterpillar.

The four parts of the Monarch butterfly's life and of the moth's life make one of the most interesting stories of how living things grow. First there is the egg. This hatches into a caterpillar which molts as it grows larger. Then the caterpillar makes a chrysalis or a cocoon. From the chrysalis or cocoon comes the butterfly or moth. It is full-grown as soon as its wings are dry.

Bees, ants, and flies are some of the other insects that grow in this way. Every kind of living thing has its own way of growing, but the butterfly, the

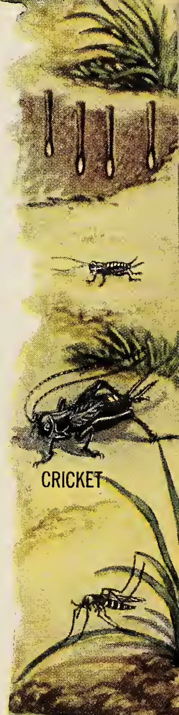


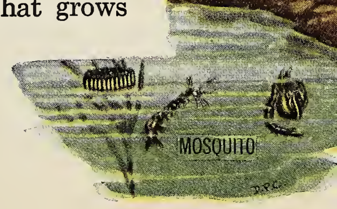
moth, and many other insects have this very strange and interesting way.

All insects go through interesting changes as they grow up, but they do not all have four parts to their lives like the butterfly and the moth. Look at the picture on this page to see how some insects change as they grow. Study the picture of the grasshopper. How many parts are there to its life?

In late summer and early autumn the mother grasshopper lays a little case full of eggs in the ground. In the spring the eggs hatch into queer little grasshoppers. They have small bodies, long legs, and no wings at all. After eating grass for a few days, they shed their skin just as caterpillars do. They shed their skin five times while they are growing. After the fifth time they are full-grown insects with wings.

The cricket is another insect that grows up in the way that the grasshopper does. The cricket, too, has only three parts to the





story of its life. First there is the egg and then a young cricket with no wings. After molting a number of times the cricket is full-grown.

* * *

Put these words in the right order to show how a butterfly grows: chrysalis, egg, butterfly, caterpillar.

Why does the caterpillar need to shed its skin?

Which changes most as it grows, a cat or a butterfly? Tell why you think so.

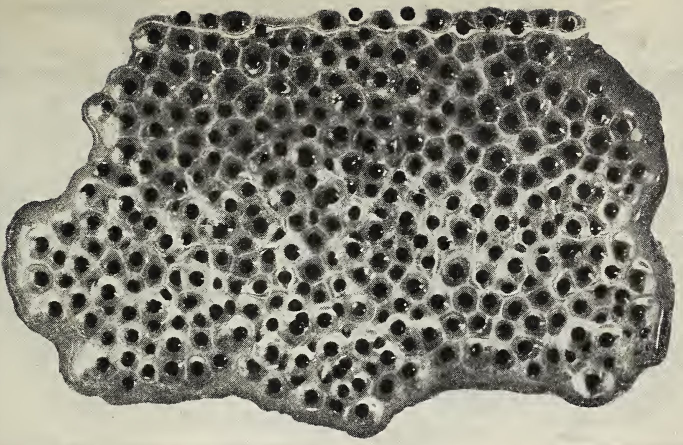
What new parts does the grasshopper add while it is growing?

How do frogs and toads grow?

Of course the boys and girls spent much time studying the animals in the school aquarium. Fish darted in and out through the plants that grew in the sand, and tadpoles swam around with wriggling tails.

The children enjoyed looking at the tadpoles because they could see that the tadpoles were changing. Two little legs had grown out from their bodies, and their tails seemed to be getting shorter, too. The children thought that watching them grow up was as much fun as a motion picture.

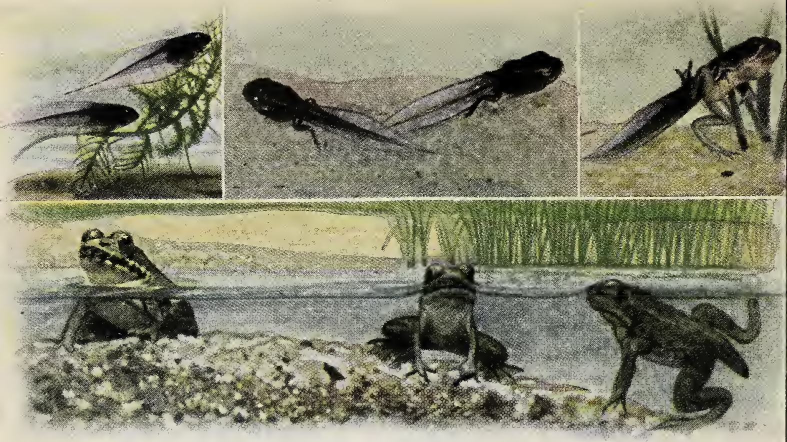
The life story of the frog is just as interesting as the story of the butterfly's life. In the spring the mother frog lays her eggs in a pond or quiet stream. She may fasten them to the stem of a water plant or to a dead tree branch in the water, or she may just



let them float. She lays hundreds of eggs all together in a kind of jelly, as you see in the picture on this page.

If you look at one of these eggs, you can easily see a little black dot in it. As the bright spring sun warms the water day after day, the black dot becomes larger. At last you can see it move. Before long that black part wiggles loose from the mass of jelly. The frog egg has hatched into a tiny tadpole.

Almost as soon as the tadpole is hatched, little fringes begin to grow on each side of his head. These are gills. The tadpole breathes with them just as a fish breathes with its gills. Slowly this little animal grows bigger. In a few weeks he makes another change. His two hind legs grow out. After a while he looks just like the tadpoles the class had in the aquarium.



The children kept close watch of the tadpoles. They wanted to see how the tadpoles changed so that they could live on land. The little animals already had two hind legs. Probably you think the next change was that they got two front legs. But they didn't. They pushed one front leg, or "arm," out first and swam around with three legs.

The class knew that another leg was coming, for they could see it folded up under the skin. And then, after a time, out came this other front leg. Now the tadpoles had four legs, and they went swimming around with their tails wiggling and their legs hanging down.

All this time the tails had been getting shorter and shorter. Finally they were just little stubs. The tadpoles were getting to look more and more like little frogs.

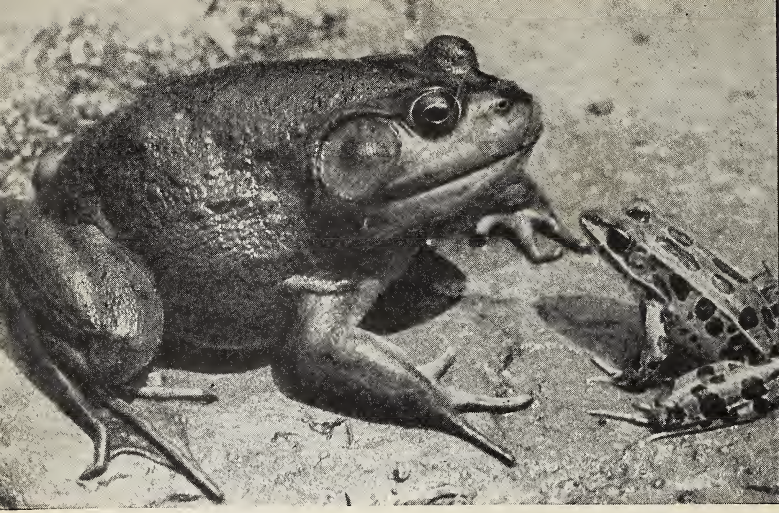
Changes also had been going on inside the bodies of the tadpoles. They were growing lungs. With these lungs they could breathe air on land. One day the class saw one of the little frogs climb slowly on to a block of wood that was floating in the water. There it sat, looking around with its funny little pop-eyes, just as if to say, "Well, here I am. I can live on land just like the rest of you." The tadpole had become a frog!

Do you think it was a grown-up frog then? Not at all. This little fellow was only about an inch and a half long, and you know that most frogs are much longer than that.

Of course this little fellow grew bigger and bigger as the days and weeks passed by. But he did the funniest thing while he was growing. If you could really see him, how you would laugh! He did the same thing the caterpillar did. He shed his skin, and this is the funny way he did it.

The old skin split down the middle of the back and the middle of the front. It also split along the tops of the four legs. Then the frog wiggled and wiggled to get out. He had to pull his legs out and his "arms" out. Frogs shed their skin several times a year while they are growing.

Some kinds of frogs grow to full size much faster than others. And some kinds of frogs are much larger than others. The bullfrog grows to be a great



The big bullfrog is several times as large as the pickerel frog beside him.

big fellow. He stays a tadpole for more than a year, and after that it may take him two or three years to grow to full size. Some frogs hatch in the early summer and are full-grown by the time winter comes.

While the class had been learning all these things about frogs, Nancy had been doing some thinking. Now she was ready with some questions.

"Frogs are amphibians," she said, "and so are toads. But I never saw a toad in the water."

"I have," said John Cole quickly. "I've seen them in the water in the spring, when I was collecting frogs' eggs. But I never saw them in the water any other time."

The toad in this picture was once a tiny tadpole. He grew in the same way that a frog grows. What new parts grew from the time the egg was hatched until the tadpole became a toad?

John had probably seen toad's eggs in the water, but he did not know what they were. The toads go to the water only in the spring, and they go then to lay their eggs.

The eggs of the toad are laid in long strings, and they are black. The jelly that holds them together is grayish in color. They hatch out into little toad tadpoles and change into little toads in about the same way that frog tadpoles change to frogs.

People and dogs and birds and cats and fish and reptiles change while they are growing, and they add new parts. But they do not change as amphibians and insects do. A fish is a fish just

How do these animals change while they are growing?

as soon as it hatches, and a bird is always a bird. Puppies are never anything but little dogs, and kittens are always little cats.

* * *

Here are some of the changes that frogs make while they are growing. Put them in the order in which they happen.

Come out of the water.
Get front legs.
Get hind legs.
Shed their skins.

Which two of these groups of animals change most while they are growing: insects, birds, mammals, fish, amphibians?

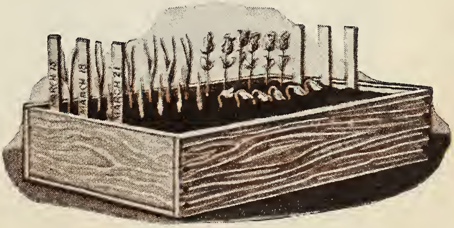
Which is older, a tadpole with hind legs or one with front and hind legs?

How do plants begin to grow?

You have learned many things about how animals grow. A tiny frog egg becomes a big frog with head, legs, eyes, and other parts. Another kind of egg grows to be a beautiful butterfly. A soft little chick in a few months is a big hen or rooster with sharp claws, a strong bill, and stiff feathers. They have all changed, and they have all added new parts to their bodies.

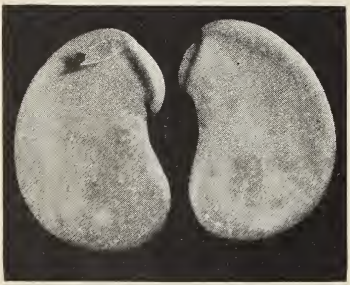
Growing plants go through just as surprising changes as growing animals. Perhaps sometime you have made a little garden. You know that a handful of seeds will grow into so many plants that you cannot get them into a big clothes basket. One little kernel of corn, about as big as the end of your finger, changes into a plant as big around as a broomstick. And it is much taller than you are.

It is easy to watch plants change as they grow. And it is fun, too. You will need a box of good soil about six inches deep. Then get a handful of bean seeds and a handful of corn seeds. In one end of the box plant one or two corn seeds, and in the other end, one or two bean seeds. Then every two or three days for two weeks plant a few more seeds. Keep your little garden watered.



Beside the seeds push little flat sticks part way into the soil. On each stick write the date so that you will know which seeds were planted first. By the time the last seeds are planted, some of the little plants will be pushing up through the black soil.

Now, how could the bean and corn plants grow from the little seeds you planted? Perhaps you can find out by taking some seeds apart. If you study the structure of the seeds, maybe you can discover why plants grow from them. But before you try to take the seeds apart, soak them in water overnight. Then they will come apart easily, and you can see the inside.

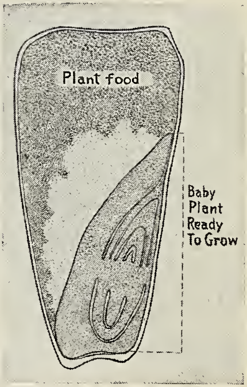


The boys and girls in Miss Burt's class had never thought of taking a seed apart. But they learned that they could do so. They found that there was an outside coat, like a skin, which slipped off the wet seed easily. They learned that they could split the bean seed into two parts like the ones you see in the picture. When they had done this, Miss Burt said, "Now I wish you would study these parts carefully and tell what you see. Use a magnifying-glass if you want to."

In a little while Nancy said, "There's something that looks like two little leaves near the end of one of the parts. But there isn't anything like it on the other half."

The other boys and girls could easily see the same thing that Nancy saw.

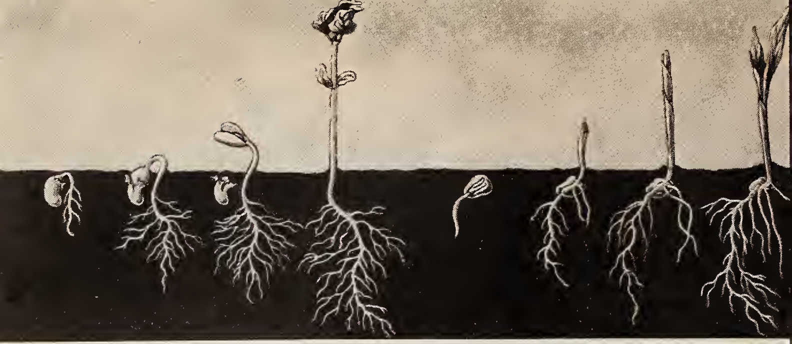
The corn seeds could not be split in two; so Miss Burt took a knife and cut them in two from top to bottom. Then she asked the class to study them carefully.



Finally John Cole said, "Well, I can't find anything like what we found in the bean seed, but down near the pointed end there is a part that looks different from the rest of the seed."

Nancy and John had discovered the parts of the seeds that show us why plants can grow from seeds. Did you find those parts in the seeds you examined? Do you see them in the pictures on this page and on page 66?

Each of those parts is a tiny plant all folded up and ready to grow. The rest of the seed is food for this tiny plant to live on while it is beginning to grow. A seed is really a baby plant with food to start it growing.



Now you are ready to discover just how the baby plant changes as it begins to grow. If you have a little corn and bean garden, dig up some of the plants. Start with the ones you planted last. Be sure to take plenty of soil with them, and wash the soil off after you have dug them up.

Examine your plants carefully, and study the pictures on this page. Then try to answer the questions below.

* * *

How can you find out what the inside of a seed looks like?

Why were the seeds planted on different days?

Which part of the plant grows out of the seed first—the root part that goes down into the soil or the stem part that grows up out of the soil?

What is happening to the seeds of the plants that have been growing longest? Why?

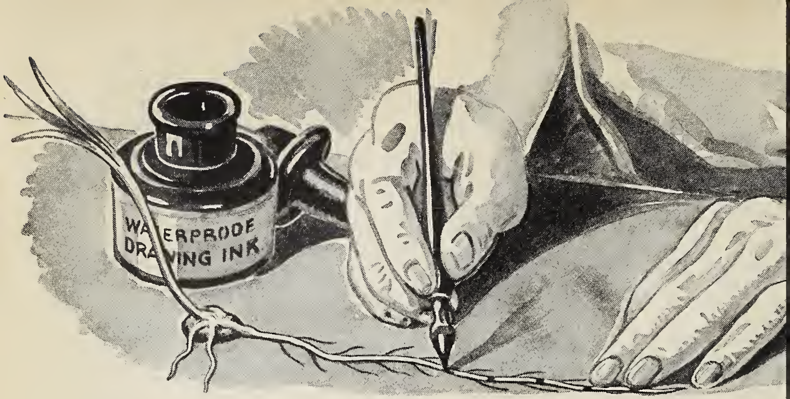
What has happened to the covering of the seed?

What has happened to the food that was inside the seed?

How do roots of plants grow longer?

On his grandfather's farm John had often seen a big tree with a rusty old horseshoe nailed to it. When John's father was a boy about ten years old, he had nailed that horseshoe to the tree. The tree was many feet taller, but the horseshoe was still the same distance from the ground. John could not understand why. He thought that the horseshoe would be moved higher as the tree grew taller.

Do you know why the horseshoe stayed the same distance from the ground? If you have a bean and corn garden in your schoolroom, you can find out for yourself how a tree grows taller and how its roots grow longer.



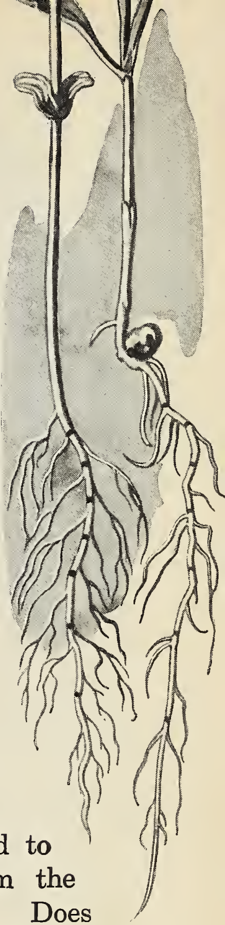
Take two or three of your biggest plants and pull them up carefully so that you will not break the roots. Wash the roots clean. Get a special kind of ink that cannot be washed off by water, and make marks on the roots. Begin very near the tip. Put the marks the same distance apart all the way up to the top of the root. If you put a ruler alongside the root, you can be sure to make the marks the same distance apart. Now plant the plants in a box of damp sawdust. It will be easy to pull them out to study them again. Keep the sawdust damp.

When Peggy, Nancy, John, and the others did these things with their plants, they of course wondered what was going to happen to the marks. But they had to wait a week or more for the plants to grow. At last the day came to pull them up and examine them. At first no one saw anything interesting. The marks were all there. Then suddenly Charley Adams noticed something.

"Why, some of the marks are farther apart than others," he said. "But when we put them on, they were all the same distance apart!"

Peggy said, "This root has grown way out beyond the bottom mark." The picture shows what the children saw. What does it show about how roots grow?

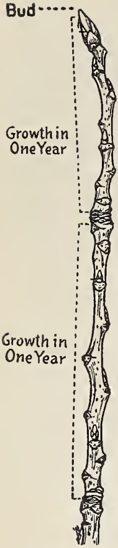
The class talked it over and decided that roots get longer by growing at the end. The last mark they had put on each root had been almost at the tip. Now the mark was much farther back from the tip. The root had grown an inch longer at its end. But the marks near the top of the root were almost the same distance apart as when they were made.



How do trees grow taller?

The horseshoe that John's father nailed to the tree stayed the same distance from the ground even though the tree grew taller. Does this tell you anything about how trees grow tall? Do you think they grow longer all the way along the trunk, or just at the top?

If you examine some twigs and branches in the

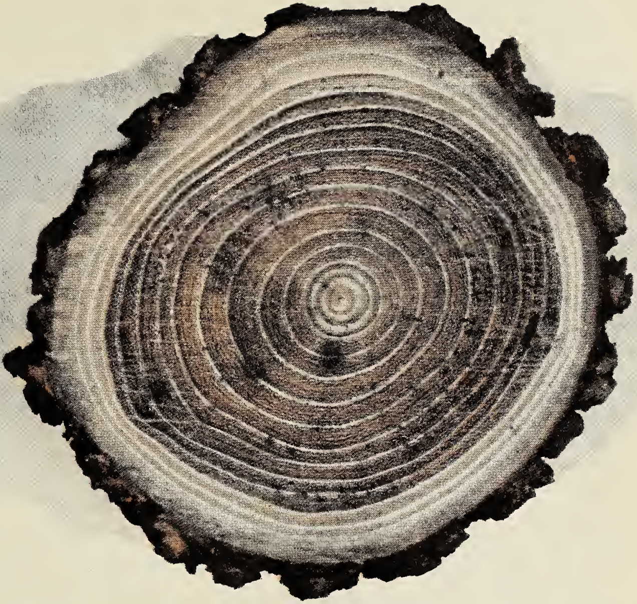


winter or early spring, you can find what happens when they grow longer. The picture on this page will help you, too. Look at the end of the twig. Do you see the *bud* at the end? If you open one of these buds, you will find a tiny stem with leaves packed tightly inside. When spring comes, the tiny stem and leaves begin to grow.

When the bud grows, it leaves a ring of rough bark around the twig. If you measure from the bud to the ring below it, you can see how far the twig grew last year. If you measure from this ring to the next ring, you can tell how much the twig grew two years ago. Now you can understand why the horseshoe never got any farther from the ground. The top of the tree trunk was the only part of the trunk that was getting longer. The stems of plants keep growing out from the end just as the roots do.

How do plants get thicker?

Of course you know that the stems and roots of plants get thicker as well as longer. But you may be surprised to learn how they get thicker. Can you find a branch or a piece of tree trunk that has been sawed across? Perhaps you have a woodpile at home where you can find such a piece. You will need a piece that has not been split down the middle.



John and Henry said that they could find such pieces to bring to class.

Next day the boys and girls examined the structure of the inside of the branches and trunk. The picture on this page shows you what they saw.

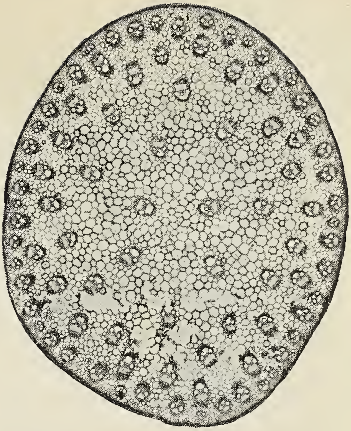
Do you see the rings in the wood? These rings show you how the tree grows thicker. It grows thicker by adding layers of wood around the outside just underneath the bark. Each ring has a light-colored layer and a dark-colored layer.

In the spring the new wood that grows is light-colored. This makes the light-colored layer. During the summer the layer of dark wood grows. In this way a light layer and a dark layer are added to the tree trunk every year. Study the picture again. Can you see these dark and light layers of wood?

Now read again what you just read about the layers of wood. What can the layers tell you about a tree? Do you see that they can tell you how old it is? Every year one ring of new wood is added. Each ring has a dark layer and a light layer. The class counted the dark layers in John's tree. The tree was twenty-eight years old. Henry's tree was twenty years old. Count the rings in the picture on page 73. How old was the tree?

You have learned that some plants grow thicker by adding layers of wood around the trunk and branches, but there are some kinds of plants that do not grow thicker in that way. Nancy, Charley, and the others in the class decided to see what the inside of a corn-stalk looks like. They cut a corn-stalk into pieces crosswise.

Soon Mary discovered something. "You can easily see how the stalks get longer. There's a hump around the stalk where every new part began to grow. But I can't find any rings inside like the ones we saw in the tree."



This is what you see when you look at the inside of a corn-stalk with a microscope.

Mary was right. There are no rings in the corn-stalk, as you can see from the picture on this page. The corn plant gets thicker by growing all through the inside. This shows us another way in which plants grow thicker. Not all kinds of plants add new layers around the stem and branches. Look again at the picture on page 73 and compare it with the picture on this page. Do you see how differently the two kinds of plants grow?

* * *

What are the two ways in which different plants grow thicker?

How could you prove that a stem gets longer by growing at the end?

If you hang a swing from a branch of a tree, will the swing get farther from the ground as the tree grows taller? Why?

Suppose it had been very hot and dry all spring as well as all summer. How might the rings for that year be different from the rings for other years?

How does food help living things grow?

As you have studied this part of your book, you have discovered many new things. You have learned what happens when plants and animals grow. You have seen how their structure changes and how they get bigger and bigger. A little acorn that you can hold in your fingers grows into a great tree higher than your house. You weighed only about six or seven pounds when you were born. You had no teeth and very little hair, and your bones were very soft. Now you weigh sixty or seventy pounds, you have two rows of hard white teeth, your bones are harder, and the hair is thick on your head.

Where do you think all your added pounds of bone and muscle and fat came from? You know, of course, that they came from the food you ate.

Can you solve this problem?

+ ? =

You took food into your body every day in every year of your life. The more you grew, the more you ate.

You ate bread and meat and vegetables, and you drank milk. Your body changed those foods to make larger bones and to add many pounds of fat and muscle to you. So, the more you ate, the more you grew!

But what made the little acorn grow to be a giant oak tree? Was it food? Yes, it was food. Plants need food to make them grow, just as much as animals need it. Of course a plant has no mouth, and it cannot move around hunting for food. What do you think the plant uses for food, and where does the plant food come from?

Did you ever hear someone say, "This is good rich soil. Plants will grow well in it"? If you have heard someone say that, you can guess where the plant gets some of the materials it needs for food It gets them from the soil. It takes in these materials through its roots, which grow through the soil in all directions.

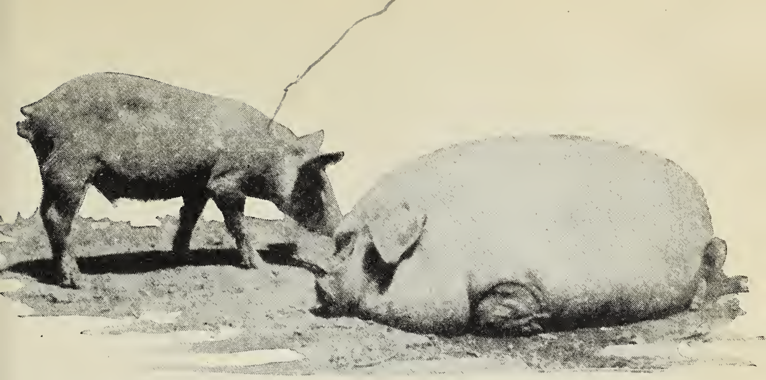
Sometimes soil does not have enough materials for plant food in it. Then the farmer and the gardener have to put something in the soil to make it richer for their plants.

Perhaps you have seen your father put plant food on the lawn to make the grass grow better. Then, if you had to cut the grass, perhaps you did not like to have it grow so fast and so thick.

But not everything that plants need for food comes from the soil. Some of it comes from the air!

Probably you never would think that a tree or a blade of grass could find anything in the air to make it grow. But a plant does get materials for food from something it takes out of the air. It takes in air through its leaves. In the next unit you will learn how air gets into the plant through the leaves, and what the plant uses from the air for its food.

Just having plenty of food will not always make a plant or an animal grow well. Living things must have the right kinds of food, too.



One of these pigs had the right kind of food to make him grow. The other had poor food. It is easy to see which one had the right kind!

John knew how important it was for growing things to have the right kinds of food.

"I have a little pig out on our farm," he said. "I'm trying to make him grow as big as he can, so that I will win a prize at the fair. My father told me how pigs have to be fed to make them grow big and fat. You certainly have to be careful how you feed them."

You can see for yourself how the right kind of food helps animals to grow. Get two white rats that are the same size and the same age. Try this experiment with them.

First, weigh each rat carefully, and put the weight on a chart. Keep each rat in a separate cage. For four weeks feed one rat only coffee and bread. Feed the other rat milk and cereal. Make a sign for

The rats are just alike at the beginning of the experiment. How do you think they will change?

each cage. Have one sign read "Bread and Coffee," and have the other sign read "Milk and Cereal." Every week weigh each rat and put the weight on the weight chart.

If you did this experiment, you found that one rat weighed more than the other at the end of four weeks. The rat that had milk and cereal for food grew faster than the other rat. One rat had the right kind of food to make it grow. The kind of food boys and girls eat is just as important as good food is to rats. The right kind of food is important to growing plants, too.

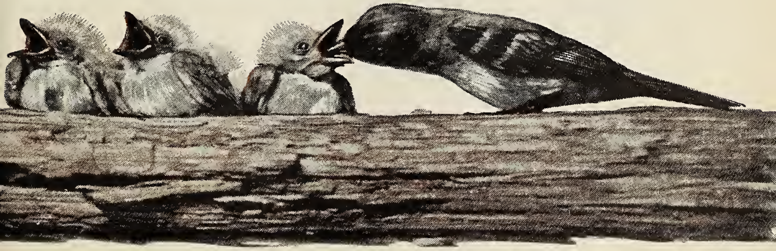
You have been learning how living things grow larger as they eat food. Let us see if we can find what we mean when we say that only living things can grow.

Did you ever make a big snowball? First you make a little ball of snow with your hands. Then you start rolling it. All the time you roll the ball, it keeps adding more snow and getting bigger and bigger.

You know that we do not get bigger that way. The snowball gets bigger by just adding more snow on the outside. But we do not get bigger by just adding more milk and bread and eggs and oatmeal on the outside of ourselves. A snowball, no matter how large it gets, is only snow. But we are not made of bread and milk and carrots and all the other things we eat.

Living things can take different kinds of food into their bodies and change these foods into the same

The mother bird feeds her babies insects and worms. They change this food into the bones, feathers, flesh, and blood that make up their own bodies.



things they are made of. That is the wonderful fact about the living things of the world. The food they take into their bodies is changed into the living material that they are made of.

Why did you weigh the rats before you began to feed them?

Which sentence below tells you what the experiment with rats shows?

a) Milk and cereal make living things grow.
b) Milk and cereal are good for children.
c) Milk and cereal make white rats grow better than coffee and bread make them grow.

Where do trees get their food?

What can living things do with food that nonliving things cannot do?

Things to Find Out

1. Find some frog's eggs in a pond in the spring. Keep them and watch them change as they hatch and grow.

2. Look for cocoons on trees and bushes. Keep them to find what comes from them.

3. Look for some caterpillars. Keep them in a box and feed them. Watch them make their cocoons. Keep the cocoons and find out what happens to them.

4. Make some cuttings of house plants. Plant them in moist sand. Keep a record of how they change as they grow.

5. Plan some experiments of your own to prove the following things:

- *a*) That some plants grow faster than others.
- *b*) That plants need food to grow.
- *c*) That animals grow faster on some kinds of food than they do on others.

6. To see how leaves grow, make a mark across a narcissus leaf. Measure from the bottom up to the mark. Measure it again in a week. How does the leaf grow?

7. Get a plant with broad leaves, like a geranium. Hold a piece of paper against a new leaf and draw the outline of the leaf. Keep the drawing. In a week or so again draw the outline of the leaf. Use the same piece of paper. How do geranium leaves grow?

UNIT 3

WHY DO LIVING THINGS NEED AIR AND WATER?

During the summer John Cole went on a long automobile trip with his father and mother. On the trip they drove through a part of our country that was very strange to them. For miles and miles there was hardly a living thing. They saw only a little grass and a few low bushes. Once in a while they saw a bird.

"Why don't things grow here?" John asked.

"Because there isn't enough water," answered his father. "Rain falls only a few times a year, and the sun is so hot that the water dries up quickly. There are many other places in the world where there is almost no water. These places are deserts. Very few plants and animals can live in deserts."

John thought that he could understand why living things need water. There was no drinking water in the car and none along the road. He was so thirsty he could hardly stand it. And he felt as if he were drying up.

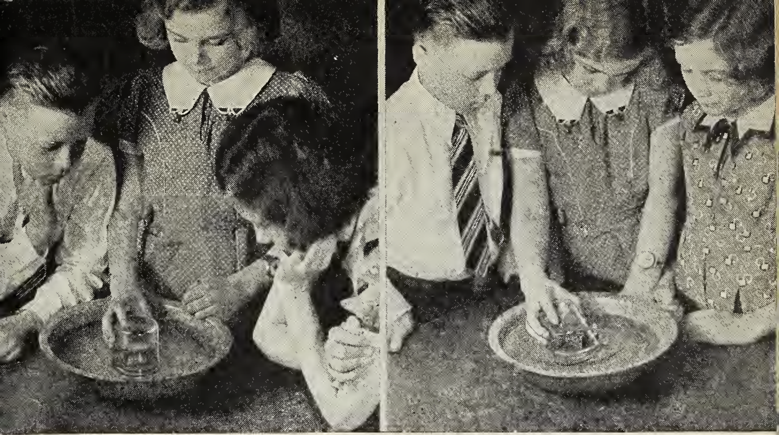
Do you have some plants and animals in your school-room or at home? If you have, you know that they need food to grow and to stay alive. But

This turtle pushes his nose above water to get something he must have. What is it?

food is not all they need. What would happen to them if you did not give them water? They must have water. Every living thing must have water.

But water and food are not enough to keep things alive. Something else is needed. When you are in swimming, can you stay under water very long? Why? What would happen to grasshoppers if you kept them in a small fruit jar with the top screwed on tight? You might put in plenty of food and water, but even then they could not live. They must have another very important thing. Do you know what it is? It is air. Living things must have air all the time. You could live about three days without water, but you could not live five minutes without air.

Now let us see just why living things need air and water to stay alive. You know, of course, that air and water are not alike. We can see water, but we cannot see air. We can drink water, but we breathe air. First, let us learn what air is; then we can understand why living things need it.



What is air made of?

We cannot see air. We cannot smell it, either. And we cannot cut off a piece of air with a knife. Yet air is just as real as anything that you can see and handle. You can prove that air really is something by doing an experiment with a water glass.

The water glass may look empty to you. But is it? If you think it really is empty, do this: Pour three or four inches of water into a pan. Put a cork on the water to help you see what happens. Then turn the glass upside down over the cork and push it straight down into the water. Did the water go up into the glass? If the glass were really empty, the water would go into it.

Something was keeping the water out of the glass. Slowly tip the glass to one side. Did some big bubbles suddenly come out of the glass and up through the water? Did some water then go into

the glass? The bubbles were air. Air had to come out of the glass before water could go in. Air takes up room just as much as rocks and wood and iron take up room.

Even though we cannot cut off a piece of air and wrap it up, still we can fill a paper bag with air. Get a paper bag and blow into it as the boy in the picture is doing. What made the bag swell out?

But air is not like wood, stone, iron, and glass. Wood, stone, iron, and glass are all *solids*. These solids cannot be poured like water. Water is not a solid. It is a *liquid*. Gasoline, milk, and oil are liquids. Air is not a solid, and it is not a liquid. It is a *gas*. Everything in the world is either a solid or a liquid or a gas.

Some kinds of gases can be seen easily because they have color. Some are blue, some are yellow, and some are green. Other gases have no color. You can smell some kinds of gases, and some other kinds you cannot smell. Can you smell or see the gas from your gas stove when you first turn it on?

Air is not just one kind of gas. It is made of many different kinds of gases. These gases are all mixed together; so we say that air is a mixture of gases. The air you breathe has in it many different kinds of gases. Two of the gases are very important to living things.

One of the gases in the air is called *oxygen.* Of course, no one has ever seen oxygen, because it has no color. No one has ever smelled oxygen, either, because it has no smell. But it is in the air just the same. You will soon learn how very important it is to living things.

Besides the oxygen there is a very small amount of another important gas in the air. It is called *carbon dioxide.* Later, when you study more about plants, you will learn how carbon dioxide helps them. There are several other gases in the air, but you do not need to know about them now.

* * *

Name three things that plants and animals need in order to grow and to stay alive.

Tell two experiments that you can do to prove that air really is something even though we cannot see it.

Name a solid that is in your school-room. Is there a liquid in your room? Is there a gas? Can you find something in your room that is not a solid or a liquid or a gas?

Name two gases that are found in air.

Where is air?

You are really living at the bottom of an ocean of air, because the earth is covered with a great layer of air. You walk around on the bottom of this ocean, and you push the air aside as you walk. How high above the earth do you think the air really goes? It goes up more than a hundred miles.

You are looking through air when you look at this page. Air is all around you. If you wave a piece of paper in the air, you can feel air pushing against it. There is air in your clothes. Hold up one thickness of cloth very near to an electric light or toward a window. Can you see the hundreds of little spaces in the cloth? Air crowds into these spaces. It crowds into every crack and corner of the earth.

Air is in one place where you probably would not think of finding it. Heat a pan of water on a stove and watch it carefully. What do you see on the bottom and sides of the pan? As the water gets hotter, do you see bubbles coming to the top and bursting? These are bubbles of air coming out of the water.

You already know that there must be air in water. Every living thing must have air. Fish could not live in water unless there was air in it for them to breathe. Plants that grow at the bottom of ponds must have air, too.

You may be surprised to learn that air is found in still another place. Drop a lump of soil into a glass of water and watch it closely. What do you see coming from the soil? These are bubbles of air.

Earthworms, moles, and other animals that live in the ground must have air to breathe. After a heavy rain you will often find many earthworms on top of the ground. The water has filled up the spaces between the bits of soil; so the earthworms have to come to the top to get air. As the water sinks down deeper into the soil, the air goes back into the spaces. Then the earthworms go back into the soil.

* * *

Tell three places where air is found.

Turn a bottle upside down and push it into a deep pan of water. Then turn it on its side. Explain what happens.

What part of the air do animals need?

Once long ago a scientist was very much interested to know how living things used air. He had just discovered that air is a mixture of gases. Up to that time everyone had thought that air was just one kind of gas. This scientist wanted to know whether animals needed all of the air or just a part of it. Almost everyone knew that living things need air, but they did not know why.

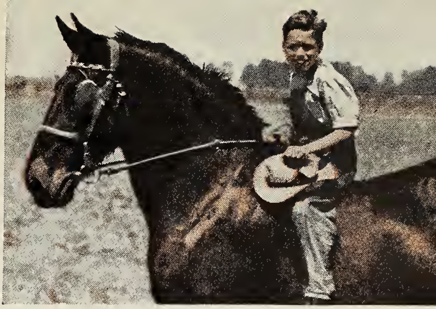
One day the scientist thought of this experiment. He took a glass jar that could be made air-tight. Then he caught a mouse and put it inside the glass jar. He closed the jar so tightly that no fresh air could get in. What do you think happened?

At first the mouse ran around and jumped up the sides of the glass jar. But soon it began to get tired. It moved about more slowly. It did not try to climb the sides of the jar, and at last it seemed to be quite sleepy.

"Now," the scientist thought, "perhaps the mouse has used up just one kind of gas that is in the air. I think I will see if it is the oxygen that the mouse has used. I'll pump some oxygen into the glass jar. I'll not put in any other gas."

The scientist began to pump oxygen slowly into the jar. What do you think the mouse did? It began to jump and run around again. It acted as lively as when it was first put into the jar. The scientist tried this same experiment with other animals. He found that they could live as long as there was oxygen. When the oxygen was used up, they died if he did not give them more. In this way the scientist found out that animals must have oxygen from the air if they are to stay alive.

Right now, as you read this, you are breathing. Have you ever stopped to think that you breathe air all day and all night long? When you breathe,



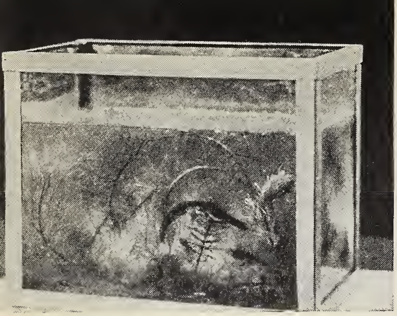
Neither the boy nor his big horse could move without oxygen.

oxygen goes into your lungs with the other gases that are in the air. When the mixture is breathed out again, some of the oxygen is left inside your body.

What do you think the oxygen does for you and for other animals? Why must your body have oxygen for you to live? This is why: Part of the food you eat gives you strength to move your body. You know that you get very weak if you go without food for very long.

But the food must be mixed with oxygen before it can do you any good. Then it can give you the strength you need to move your head, legs, arms, and the other parts of your body. Not one part of your body could move without oxygen. Even your heart would stop. Now do you understand why all animals must have the oxygen that is in the air?

Many animals have lungs for breathing. Think about the different groups of animals that you studied in the first part of this book. Dogs, horses, rabbits, and all other mammals have lungs. Animals that belong to the reptile group and to the bird group breathe with lungs, too. Insects get air through tiny holes in the sides of their bodies.



Fish can get more air in this kind of aquarium than they can get in a round bowl.

How do fish get oxygen? Do you remember the experiment that proved that there is air in water? Fish take water into their mouths and force it out over gills at each side of their heads. These gills take oxygen from the air that is in the water. Oysters, clams, crayfish, and some water snails have gills and can breathe in the water.

Some other water animals cannot get oxygen from the air that is in the water. Whales and seals are mammals. They breathe with lungs just as we do. They can stay under water for a long time, but after a while they have to come to the top for air.

Even though animals get air in many queer ways, all of them must have it.

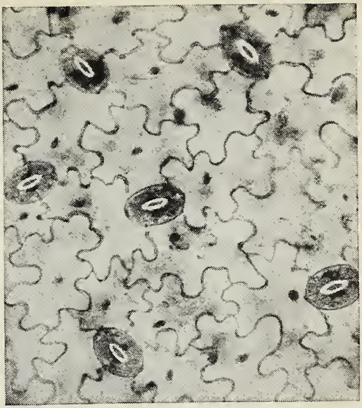
* * *

What was the scientist trying to find out about air and living things?

What did scientists have to discover before they could find out how living things use air?

Why should we sometimes change the water in a fish bowl?

A geranium leaf looks like this through a microscope. Can you see the little round "mouths" with their light-colored "lips" and dark openings?



How do plants use air?

Plants, too, need air. Do you know how they get it? If you could examine a geranium leaf with a microscope, you would find that there are many tiny openings in the leaf. There are more of them on the underside of the leaf than there are on the upper side. Now let us find out just how important these little openings are to the plant.

Spread some vaseline on both the upper and lower sides of all the leaves of a small potted plant. This will fill up the openings. Watch your plant and see what happens to it. It may be some time before any change takes place. Do the leaves get yellow and drop off? Does the plant finally die? Do you know why?

Air passes into the leaf through these openings. If these openings are stopped up, the plant cannot get air. And if it does not get air, it dies.

In the summer the openings in leaves of plants by the side of a dusty road sometimes get filled up with dust. If there is no rain to wash the leaves and clean out the openings, the leaves drop from the plants. In cities where dirt and dust from many factories cover the leaves, it is very hard to grow some plants.

Now let us see what plants do with the air that goes in through the tiny holes in the leaves. They use a part of the air that animals do not use.

The oxygen in the air helps the plant in the same way that it helps animals. The plant, as you know, must have food to stay alive and grow. Without oxygen the plant could not use food. But there is another gas in the air that green plants must have. This gas is carbon dioxide. Animals breathe carbon dioxide out into the air. But plants use it.

Now what do you suppose plants use carbon dioxide for? Green plants use it to make food. Animals do not make their own food, but green plants do. They take materials from the soil through their roots. They take carbon dioxide from the air. Then, inside the plant the materials from the soil are put together with the carbon dioxide to make food for the plant. So you see that plants

Can you take materials from air and soil and make a pumpkin out of them? A pumpkin plant can! Plants made all these vegetables out of materials from the soil and from the air.

need two gases that are in the air. These gases are oxygen and carbon dioxide.

* * *

Tell two ways in which plants use air.

What gas in the air do all living things use?

Can you find anything in this list of things that does not need oxygen: A cat, a tree, a stone, an insect, a fish, a dead tree, and a bird?

Where is water found?

There was plenty of air in the desert that John and his father and mother saw on their automobile

Here is a place where water comes out of the earth and shoots high into the air!

trip. Plants could get all the oxygen and carbon dioxide they needed. Animals had plenty of oxygen. Yet very few plants and animals could live in this desert country. There were no farms with fields of corn and wheat, and no herds of sheep or cows. In all this desert country there was very little water, and living things must have water to stay alive.

Since every living thing must have water, it is a good thing that water is found almost everywhere on the earth. The water in oceans, seas, lakes, and rivers covers about three-fourths of all the earth. Get a map of the world and look at the places that are colored blue. They are the oceans, lakes, and seas. You can see that they cover much more of the earth than the land does.

But not all of the water is in these oceans, lakes, and rivers. Some of it is in the ground. When you sprinkle your lawn, you can see the water soak into the earth. When it rains, much water soaks down into the earth. We put pipes down into the ground and pump water up so that we can use it.

Jane's mother had promised to take her to the park for a picnic with her friends. On the day of the picnic Jane said to her mother, "Oh, Mother! It rained last night. The grass and trees are very wet. We shall not be able to have our picnic."

But Jane's mother looked at the sky and said, "All the clouds have gone, and the sun is bright. By afternoon the leaves of the trees, the grass, and the swings in the park will all be dry."

When it was time for the picnic, Jane found that her mother was right. Do you know where the water had gone? Where does the water go when your wet swimming-suit dries? Perhaps you can tell if you try this easy experiment.

Pour water into a glass jar or a drinking-glass. On the outside of the glass make a mark with ink to show just how much water there is in it. Make a sign saying, "Please do not touch," and set it by the glass. Look at the glass of water every day. What is happening to the water? Where do you think the water goes?

Does all the water finally disappear? When water disappears into the air, we say it *evaporates*. The water

changes from a liquid to a gas and mixes with the other gases in the air. When water has turned into a gas, we call it *water vapor*. Every day water is evaporating from places on the earth.

Water evaporates from wet ground, from wet grass, and from wet trees. Water is always going into the air from lakes, oceans, rivers, and creeks. Do you see now that there really is water between your eyes and the page of this book?

How did water get on the outside of the cup?

Perhaps you are wondering whether this water ever gets out of the air again. Here is an easy way to find out. Take a tin cup and fill it with ice that has been chopped fine. Stir the ice and watch the outside of the tin cup. What do you see on the outside of the cup? Where does this water come from? Can it come from the inside of the cup?

If you have used a good tin cup, there were no holes for the water to get through. If your hands were dry, the water could not have come from them. There is only one place where the water could come from. It had to come from the air around the cup. The ice in the cup made the air cool when the air touched the cup. Cool air will not hold as much water as warm air. So some of the water came out of the air and settled on the tin.

Have you ever watched water fall out of the air? Rain is water coming out of the air. Sometimes water comes out of the air as dew. Sometimes it freezes and comes as hail or sleet. Snow is water vapor that has frozen out of the air.

* * *

Tell the missing word or words in each sentence below.

1. When water goes into the air, we say it ______.
2. Water changes to ______ ______ when it goes into the air.

Does water come out of the air when the air gets warmer or when the air gets cooler?

Why must plants have water?

Do you know why plants must have water? There is something very wonderful that water can do. Let's find what it is. Then we can understand why both plants and animals need water.

Suppose someone asked you to pass a lump of sugar through a cloth without tearing the cloth. How would you do it? Perhaps you think you could not do it, but try this experiment: Drop the lump of sugar into a glass of water. Stir the water until you can no longer see the sugar. Taste the water. Where is the sugar? Now pour the water through the cloth. Taste the water again. Did the sugar go through the cloth? Of course you could do the same thing with some salt. Try it.

Scientists say that the water *dissolved* the sugar and the salt. Water is the world's best dissolver. It can dissolve more things than any other liquid can.

Now let us see how water helps plants because it can dissolve things.

Perhaps you have watched your father spread *fertilizer* on your lawn. The fertilizer is made of materials that the plant needs for food. But the fertilizer does not help the grass to grow if it is left on top of the ground. So your father sprinkles the lawn. Or he waits for the rain to fall. The water that falls on the lawn dissolves the fertilizer. Then the water soaks into the ground. When it soaks down where the roots of grass are, the roots begin to take in the water. The fertilizer goes into the roots with the water.

Now you can see how plants use water. Plants could not live in the best soil in the world if they did not have water. In the soil are materials that the plant needs to make food. But these materials have to be dissolved in water before they can soak into the plant roots. Plants could never get the food from the ground if the water did not bring it in.

Let us see if we can find another way in which water helps plants. Put some red ink into a glass of water. Then put several stalks of celery into the red water. Watch the celery for a while. How long does it take the red water to go up the stalk and reach the leaves?

Water is the world's best dissolver. It is also the world's best carrier. It can go from one place to another very easily. As it moves, it carries along the materials that are dissolved in it. The water that soaks into the roots of the plant travels all through the plant. As it travels, it carries food that every part of the plant must have. This watery liquid that travels through the plant is called *sap*.

Here is an easy experiment to show you that plants need water to grow. Get a yard or more of white cloth. Fold it several times until it is about the size of a handkerchief. Now sprinkle the cloth with water until it is quite damp. Lay about two dozen bean seeds on the cloth; then roll it up with the seeds inside. Sprinkle the cloth every day.

Take another cloth the same size. Fold it and roll it up the same way with seeds inside. Do not wet this cloth. Keep both of the cloths in the same place for a week; then open them up and examine the seeds. What do you find? Tell why something happened to one group of seeds that did not happen to the other group.

The baby plants in the seeds could not use the hard food that was around them. But the water in the wet cloth dissolved the food and changed it so that the tiny plants could soak it up and use it to grow.

* * *

Water helps plants in two important ways. What are they?

How does water help seeds to start growing?

Choose the right word for this sentence: Water *evaporates* *dissolves* food for the plant.

Why do animals need water?

Almost every kind of animal in the world must have water just about every day. You can live for a month without food, but you would die in about three days without water. More than one-half of your body is made of water. If you stopped drinking water long enough, your body would dry up like the leaves and the grass in the hot summer months.

Why do our bodies and the bodies of other animals need water? Water helps our bodies to use food. The food we eat has to be dissolved before our bodies can use it. The water we drink helps dissolve the food we eat. You would have a hard time swallowing dry cookies and bread if the *saliva* in your mouth did not moisten them for you.

In this water-hole is the only water for many miles. What would happen to the cattle if the water-hole should dry up?

This saliva is made partly of water. There are many juices in your body that keep food moist and dissolve it. Your body cannot use dry food any more than the baby plant can use the dry food in the seed. Without water your body could not make these juices that change food so that we can use it.

The blood of animals is made up mostly of water. If they did not have water to drink, they would not have blood to keep them alive. The blood in your body acts in much the same way that sap in a plant does. It carries food and oxygen around inside your body.

When you eat food, all you need to do is to chew it and swallow it into your stomach. But it has to go down to your toes and up to your arms and head. Every part of your body needs some of the food. The blood carries the food to all parts of your body. Do you see now why someone once said, "Without water nothing could stay alive"?

* * *

If you weigh seventy pounds, about how many pounds of water are there in your body?

When you are thirsty, how does your mouth feel?

Why must your body have water to use food?

Questions to Think About

1. Why does a person die if he stays under water too long?

2. When aviators try to find how high above the earth they can go, they take along tanks of oxygen. What does this tell you about the air far above the earth?

3. Which gas in the air helps living things use food? Which gas helps plants make food?

4. Why is rain important in the spring after you have planted your gardens?

5. Where does the drinking-water in your home come from?

6. About how many quarts of water do you drink in a day?

7. How does a plant look when it needs water? How does it look after it has been watered?

8. What happens to the farmer's corn and wheat if there is no rain?

Things to Find Out

1. Find out how fresh air is kept coming into your school-room.

2. Prove to your class that:
   - *a*) There is air in a glass bottle.
   - *b*) A solid can be changed to a liquid.
   - *c*) A liquid can be changed to a gas.

3. How do deep-sea divers get air?

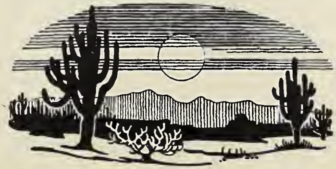
4. Cut open the stalk of celery that you placed in red ink and find the parts that are colored. These colored parts carry the water to the leaves.

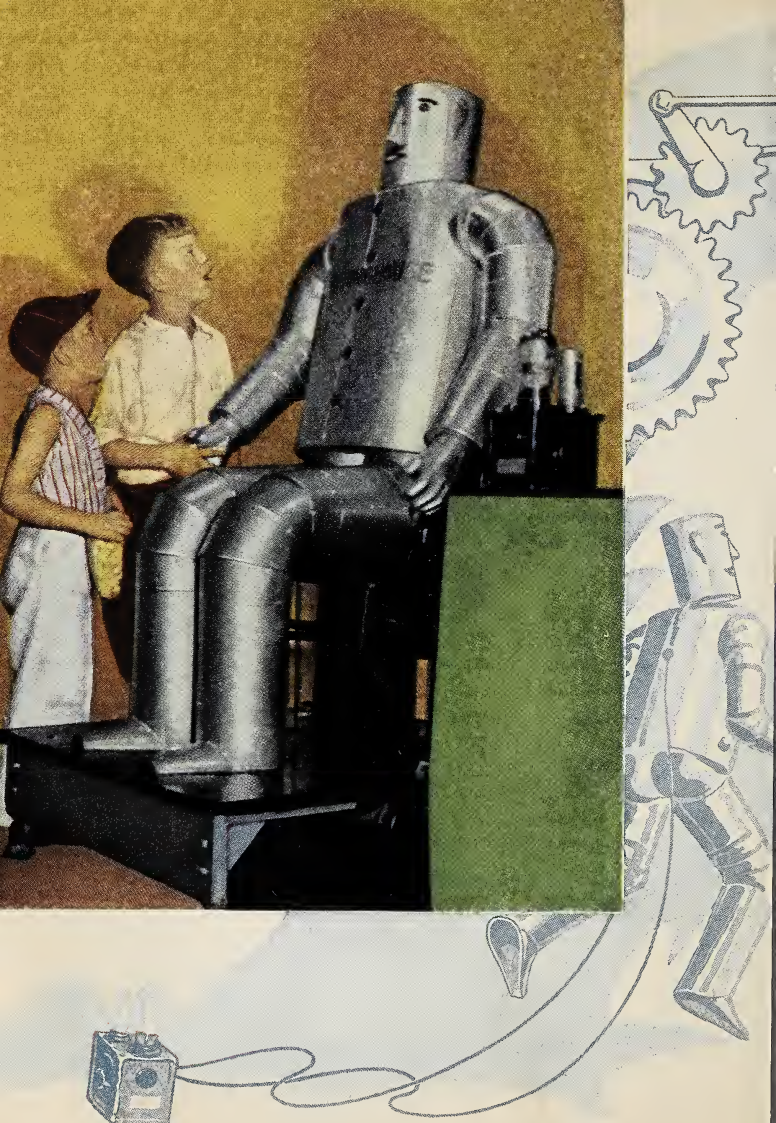
5. Dig up a dandelion plant out-of-doors and look at the roots. Are they longer than the roots of the grass? Why can a dandelion plant stay green longer than grass in the dry summer months?

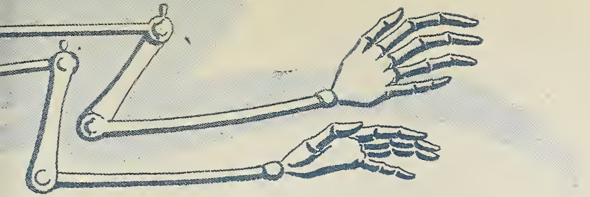
6. Plant some corn seeds and after a week has passed, look at the roots. Can you see the fuzz on the roots? This fuzz is made of hundreds of tiny roots. They take in water. Look at them with a microscope.

7. Find some green leaves and look for the parts of the leaf that carry water.

8. Find out if there is water in a peach or in an apple. First weigh one of these fruits. Heat it for a long time in an oven; then weigh it again. The heat made the water evaporate from the fruit. Was there much water in the fruit?







UNIT 4

HOW DOES THE BODY WORK?

When the boys and girls of a science class came into the room one day, they found these sentences written on the board:

I am the best machine in the world.
I can lift things without breaking them.
I can remember things I do.
I can change a glass of milk into part of me.
I can tell if anything comes near me.
I need something to make me go, and I can get it myself.
I can run myself.
I can repair myself.
There are millions of machines like me.
What am I?

They all tried to guess the answer. Bobby said, "It's not an automobile, because the machine in the riddle can lift things and tell when anything comes near it. An automobile can't do that."

Henry said, "I never saw a machine that can run itself and repair itself."

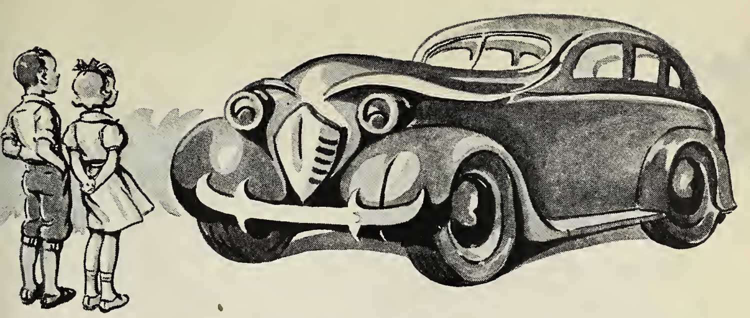
This picture shows many machines that can do all the things told about in the riddle.

Finally the teacher said, "There are thirty of these machines in this room now. They are all running. They can all do the things told in the riddle."

Then Helen guessed the right kind of machine. "You mean the boys and girls!" she said. "We are the machines that can do all of these things."

How is your body like a machine?

Have you ever thought of your body as a machine? If you will look at the engine of your father's automobile, you will see that it is made of many parts. There are big parts and little parts, parts that move, and parts that do not move. But every part helps to make the machine do the things we want it to do. Even though you and the machine look very different, your body and the machine are really alike in many ways.



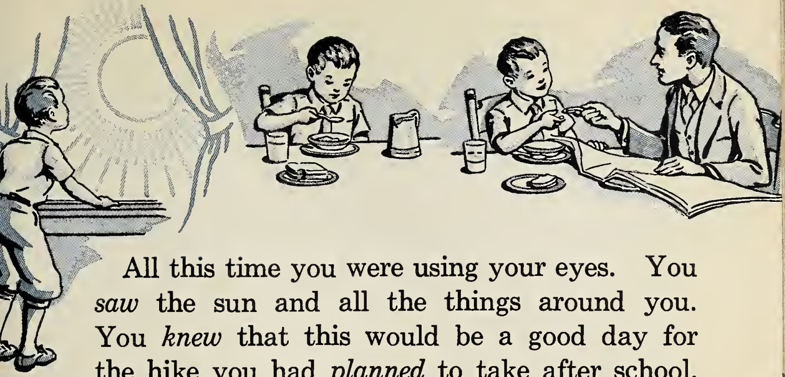
Of course, you have no gasoline tank that must be filled often. Your body does not use gasoline and electricity to make itself move. But you do have a stomach that needs filling with food three times a day so that you will have strength to move. There are no rods and pieces of iron in your body to hold it together. But you have bones and muscles that hold your body in shape and make it stand up.

There are hundreds of parts to your body. You have a *head*. There is a middle part of your body called the *trunk*, and you have other parts called *arms* and *legs*. Inside your head and trunk there are dozens of other parts, just as there are in the automobile.

In many ways your body and its parts are like the engine that runs the automobile. But your body is able to do many things that the automobile engine cannot do. There is no other machine on earth so wonderful as the human body.

Name the things that the body machines of these children are doing.

Did you ever try to count the different things your body machine does? Try to remember what it has done since you got out of bed this morning. One part of your body did some work that made you *hear* your mother call you. Many parts of your body worked together so that you could *dress* yourself and *wash* your hands and face. Just as you finished washing, you *smelled* some of the good food that your mother was cooking for your breakfast. You *ran* down to eat.



All this time you were using your eyes. You *saw* the sun and all the things around you. You *knew* that this would be a good day for the hike you had *planned* to take after school. You *tasted* the food you ate for breakfast. You *remembered* to ask your father if you could use his knife. When he answered, you *knew* what he said.

Count up the things your body machine did. You heard sounds, dressed yourself and washed, smelled food, ran, saw many things, and tasted food. You listened, and you talked. You remembered, and you knew what people were talking about. All of these things you did before you had been out of bed an hour. Can you think of any other machine that can do so many different kinds of things?

Men who repair automobiles learn all about these machines, so that they know how every part works. Doctors are men and women who have spent many years studying the human machine. They know how the parts work, just as the repair man knows about an automobile. When your body machine is not working well, you go to a doctor.

He examines your body machine very carefully to see if he can find anything wrong.

The doctor's work of repairing is not so easy as the repair man's job. He cannot give you a new machine part or a whole new machine. Your body machine must last all your life. The doctor can tell you what to do to help your body repair itself or keep it from breaking down. If you are to drive your body machine well and keep it from being taken to the "garage," you need to know about its parts and how they work. Then, you can help it keep in good running order.

* * *

On page 108 is a picture of a machine that looks like a man. It is run by electricity. When the electricity is turned on, the electric "man" moves. He sits down, stands up, walks, and shakes hands. When the electricity is turned off, he stops moving.

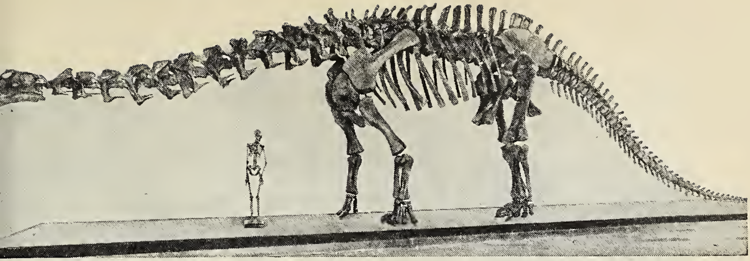
Tell three ways in which your body is like this machine "man." What can your body do that the machine cannot do?

Try to think of a way in which your body can repair itself if it is injured.

What does the human machine use to make it go?

What are some of the things that tell you that your body machine is not working well?

Why should you know some of the important things about your body machine?



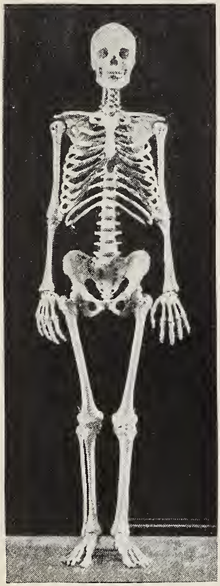
Here is the skeleton of an animal that lived thousands of years ago. You may think that a man has a large skeleton, but how small it looks beside the framework this animal had!

What gives the body its shape?

Did you ever see or hear of an animal called a jellyfish? Just from the name, what do you think a jellyfish looks like? You have probably guessed. It is just like a mass of jelly floating in the water. It hasn't a bone in its body. Your body would be almost like that if you did not have a framework of bones to hold up the soft flesh.

Of course you have seen many kinds of bones—chicken bones, fish bones, turkey bones, pig bones, and cow bones in meat that you eat. Perhaps, when you have been out in the woods or fields, you have found the bony framework of some animal that has died.

We need a framework, just as an umbrella needs its steel ribs and its handle, and just as a house needs rafters and beams. The bones that make up the framework of your body are called the *skeleton*. How many bones do you think there are in your skeleton? There are over 200! Now let us see what this framework of ours is like.



There are long bones and short ones, flat ones and round ones. Some of them are broad and flat; others are long and narrow. Many are very small. Can you feel some of these bones in your fingers, arms, and legs? All of these bones are parts of your framework or skeleton.

Look at the picture on this page and find the long row of bones up the back of the body. These bones are called the *backbone.* They are called the spine, too. The backbone holds your body up just as a pole holds up a tent. But it is also made so that you can bend it.

Someone once said that this backbone is like many spools put together on a string. Can you see in the picture that it is made up of many small bones? Press your fingers tightly against your backbone. Do you feel the places where the bones come together? Each one of these little bones is hollow, and down through them is a white cord called the *spinal cord.*

Between each of the bones there is a soft cushion that acts like a pad. These little cushions keep the bones from grinding against each other when they move. Do you see now why you can bend your back so easily?

* * *

Tell how the spine is made so that it can bend easily.

What does the backbone do for us?

Where do you think your largest bones are? Where are the smallest bones?

How do our bones protect us?

The backbone does something more than help us to stand up straight. It holds the rest of the body framework together. What would happen to the bones of the head if there were no backbone? What would happen to the *ribs?* Can you see how important the work of the backbone is? Many of the other bones of the body are joined to the backbone.

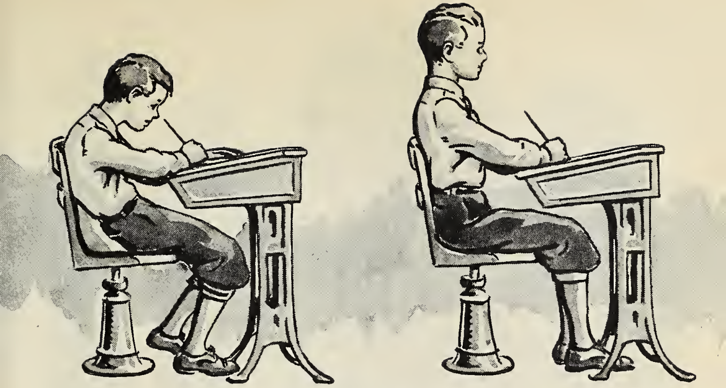
Some parts of your skeleton hold your body up. Other bones protect some of the tender parts of your body. Look at the picture and find bones that protect parts of the body. Do you find the ribs? Can you see how they make a cage that helps keep the heart and lungs from being hurt?

Feel your own ribs. Can you feel how close together they are? Perhaps you may be able to count them. There are twelve of them on each side.

Another very important group of bones make a rounded, box-like covering for your *brain*. This is called the *skull*. Sometimes boys find skulls of rabbits or other animals in the woods and bring them to school. It is easy to see that these bony skulls are a strong cover. They protected the brains that once were inside them. Find the skull in the picture of the skeleton on page 116. When you turn head over heels, your brain is protected by these skull bones. They keep your very tender brain from being hurt. Feel the bones of your skull.

You have learned that all of these bones in your body become larger as you grow. You also know that they become harder as you grow older. When you were very young, your bones were so soft that they were easily bent. If a baby stands on his feet before his leg bones have grown hard enough, his legs may bend, and he may become bow-legged.

Boys and girls often slide down at their desks in school and sit in such a way that the backbone is bent out of shape. As they grow older, the backbone may harden in this shape. A bent backbone makes it very hard for a person to hold himself up as straight as he should. If he does not hold



Which boy is taking better care of his body machine? Why do you think so?

himself up straight, the body parts inside the framework become squeezed and cannot do their work the way they should.

⁂

Tell two important things that our bones do for us.

How have your bones changed since you were a baby?

What can you do to help your skeleton grow straight?

How can the body move?

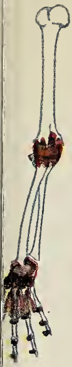
The boys and girls in the Elm Place School were going to have a marionette show. Betty was making a marionette farmer. It was the first time she had ever tried to make one.

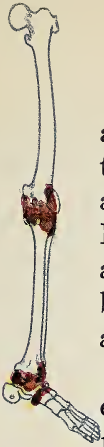
"My farmer Jim is finished," she said. "But I don't think he will ever move. He is so very stiff."

"You must make joints in his arms and legs so that the parts of his body can move," said Betty's teacher. "You have made his body all in one piece. I'll help you make the joints. Then we will fasten strings to every part of his body that we wish to move. I think you will be able to make him walk, run, and even load hay into a wagon if you can work the strings well enough."

Your body framework would be about as useless as Betty's marionette if your bones were all joined solidly together like the legs and arms and back of a chair. Of course, the bones must be held together, but each bone must be able to move.

Look on the next page at the picture of the bones of the arm and leg. Find the elbow. The elbow is the place where the bones in your arm are joined together. We call this a *joint.* The bones





are held together at this place by a tough cord. This cord lets them move and keeps them from coming apart. Look carefully at the picture of the arm bones and then try to feel the bones in your own arm. Bend your arm and feel the bones and the joint.

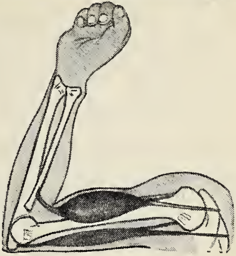
There are joints in your body at every place where the bones need to move. There are joints in your legs and toes so that you can bend them as you walk. Where are the joints that make it possible for you to play a piano or to hold a pencil? Look at the picture of the skeleton and find places in the body that have joints so that bones can move.

But joints would not make Betty's marionette move. How did she make the marionette move? To move its arms, she fastened strings to the arms. When she pulled the strings, the arms moved. To move its legs, she fastened strings to them, too. The head could not move, either, until it had a

string to move it. Bones and joints will not make your body move. Your body really has hundreds of parts whose job it is to move you.

The strings that Betty tied to the parts of her marionette acted much as the movers of your body do. Look at the picture on this page. It shows the *muscles* of a body. These are the movers of your body. You see that there are muscles in the arms, legs, back, and feet. Most of the muscles are fastened to the bones. They are fastened so that when the muscle moves, the bone must move also.

An easy way to see how muscles work is to watch them in your arm as you lift a book. Roll your sleeve up as far as you can. Pick up a heavy book and lift it slowly toward your face. Watch the big muscle in the upper part of your arm. What happens to it when you lift the book? Do you notice that it gets thicker and shorter? Now slowly lay the book back on the table and watch the muscle. See it get thinner and longer.



As the muscle gets shorter and thicker, it bends the arm.

Can you see how the muscles work to lift the book? You remember that the muscles are fastened to the bones in your arm. If the muscle pulls, it pulls the bones, and they bend at the joints. When your arm is straight, the muscle is long. As you lift the book, the muscle gets shorter. As it shortens, it pulls the bone with it. This lifts the hand with the book in it. All of your muscles work in this way.

Muscles grow strong if they are exercised in the right way. Many of the things that boys and girls like to do help to make their muscles strong. Swimming, skating, and playing ball are all good for building strong muscles.

* * *

Do you think your shoulder joint is different from your elbow joint? How is it different?

Is there any other joint in your body that moves much like your shoulder joint?

Where are the joints that move when you do these things: run, eat, swim, write, talk, ride a bicycle?

What have you done today to make your muscles grow strong?

How does the body use the food we eat?

Do you ever wonder what happens to food you eat when it gets into your body? After you eat your breakfast, things happen inside of you that you do not even know about. Your body changes your breakfast so much that you would never guess that it once had been an orange, toast, milk, and an egg.

Some of your breakfast is being made into part of yourself. Some of it is giving you strength so that you can walk to school, and some of it is used to make you fat. You have already learned that some of it is helping you to grow. All of it is being changed in some way. Let us see just what happens to your breakfast after you eat it.

First, you put your breakfast into a chopping box. Probably you have never thought of your mouth as a chopping box. But it really is. There are two rows of white choppers in this box. They are your teeth. And they begin to work on your breakfast as soon as you put it into your mouth.

The front teeth are cutters. They bite into a piece of toast and cut it into smaller bits. Next to these cutters there are some very sharp, pointed teeth. They help to cut and tear the food into pieces. Rub your tongue across these front teeth and feel

how sharp they are. Toward the back of your mouth are the flat grinders. They grind and grind the food.

In your mouth a juice called *saliva* is added to the food while the grinders and cutters are working. This juice wets the food and makes it easy to swallow. A very important thing to remember is not to hurry the work of the chopping box. Make it do its work well. Do not swallow the food until the cutters and grinders have broken the food up and mixed it with juice from the mouth.

A chopping box is not much good unless it has good choppers. Keeping your teeth clean is very important. After you have eaten, some of the food stays on the teeth and in between them. This should be brushed out every night and every morning. The food that stays in between your teeth begins to decay. It may cause your teeth to decay, too. Then your chopping box will not do a good job, because its choppers are poor.

The food you swallow goes down a tube to your *stomach*. This tube is about ten inches long and about an inch across. It goes down your neck and joins the back of your mouth with your stomach.

When the food gets into the stomach, it is ready for about an hour of mixing. We can think of our stomach as a mixing bowl. The walls of the mixing bowl are full of muscles that move the walls back and forth. They squeeze the food and move it from one side to another. These walls also pour a kind of juice on the food. After a time most of the food has been changed into a liquid. Then it is ready to leave the stomach.

From the stomach the food goes into a long tube called the *intestine.* The intestine is about twenty feet long and an inch through. It folds together in somewhat the way that a fire hose is folded. Food stays in your intestines about three hours. The walls of this long tube pour more juices on the food. All these juices help to change more and more of the food into a liquid.

The liquid food is ready to go from the intestine into all the other parts of your body.

* * *

What happens to a piece of bread after you put it into your mouth?

Why should you brush your teeth? How often should you brush them?

Food helps you in three ways. What are they?

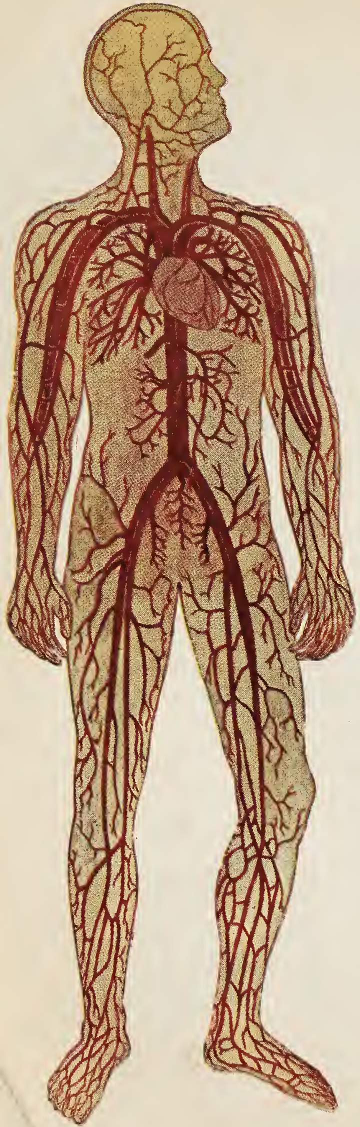
Why does your mother often tell you to eat your lunch slowly?

How is food carried to all parts of your body?

Food cannot help you grow or do you one bit of good if it stays in the intestine. It is like the food in the grocery store near your home. As long as the food stays there, you cannot use it. It must be brought to your house first.

Every part of your body needs some of the food that is in the intestine. Your head needs some of it, and so do your feet. Some must be taken to your arms, to your fingers, to all of your muscles, and to your brain. How do you think this food is carried from the intestine to all parts of your body?

Something must carry the food to all parts of the body. This carrier is the blood. It flows in a



steady stream through little tubes. The tubes branch out in all directions until they reach every part of your body. On your arm you can find some of these blood tubes. We call them *blood-vessels.* Can you see how they branch out? Finally they get so small that they can reach even the smallest part of you. This picture shows the wonderful network of blood-vessels that reaches every part of your body.

But just how does this red carrier get its load of food? There are thousands of these tiny blood-vessels in the sides of the intestines. Because the food has been changed into a watery liquid, it can soak into the blood-vessels.

Then away it goes, riding along in the blood. As this stream of blood flows all through your body, it leaves some of the food that it is carrying. It leaves food in

all the parts of your body, just as a grocery wagon might leave food at your door and at the doors of all your neighbors.

Do you know what keeps this food carrier moving? It is the heart. When the blood has given up all of its food, it goes back to the heart. Your heart is really a big muscle, and it acts like a pump. It fills with blood, and then it squeezes together and makes the blood go out into the blood tubes again. In another second it fills with blood again. Another squeeze, and out goes the blood. This pumping keeps the blood flowing through the blood-vessels day and night.

* * *

How does the food get into the blood?

What does the heart do?

Why is it important for the heart to keep doing its work?

How can you tell that your heart is beating?

How does your body get air?

How long do you think you could live if you stopped breathing? Not more than three minutes! Your body must have the oxygen that is in the air. You could not move without oxygen, and you could not grow without it. Now let us see how oxygen gets to all parts of your body.

When you breathe, you take air into your lungs and then send it out through your nose and mouth. Suppose you take a deep breath and see what happens. Do you feel your ribs move out? As they do this, air from the outside rushes in, and your lungs fill with air. Now breathe out. You can feel your ribs move back in again. As they do this, they push the air out of your lungs through your nose and mouth.

Did you notice how air gets into your body? It goes in through your nose. From your nose the air goes into your windpipe. The windpipe goes down the front of your neck and then branches into two parts. You have two lungs, and one branch of the windpipe goes to each lung.

Your lungs are somewhat like two big sponges, with hundreds of tiny air-pockets in them. After the windpipe branches into two large parts, each of these parts keeps branching into smaller and smaller tubes. Every one of the tiny branches ends in one of the small air-pockets in the lungs. When you breathe in, these little pockets fill with air, and your lungs get larger.

Every part of your body needs some of the oxygen that goes into your lungs as part of the air you breathe. There must be a carrier to take the oxygen, just as there is a carrier to take the food from the intestine. You remember that the food is carried by the blood. The blood carries the oxygen from the lungs, too.

The blood gets the oxygen through the walls of the tiny air-pockets in the lungs, just as it gets the food through the walls of the intestine. The walls around these tiny air spaces are so very thin that the oxygen can soak through them into the blood. When it gets into the blood, it is carried everywhere that the blood goes. It is unloaded all through the body while the food is being unloaded.

We need to breathe deeply so that air gets down into every one of those little pockets in the lungs. We should sit up straight and stand up straight so that we can breathe deeply. When we are all hunched over, our ribs are crowded together. They cannot move out to make room for the lungs when the lungs swell with air. Exercise helps to make our lungs strong. It makes us breathe fast and deep. This sends air down into almost every part of the lungs.

* * *

Explain where the air goes when you breathe it into your nose.

Where does the blood get the oxygen to carry through your body?

Why should you sit up straight and stand up straight?

How is the body covered?

All the hundreds of body parts must have a covering of some sort to keep out the dirt. You know that we call this covering the *skin.* It covers your body from head to toe.

When the skin covering of your body is broken in any way, you should take care of the broken place. A cut in the skin is an open door for poisons that may make you sick. Boys and girls sometimes do not take care of a cut or burn. Then the broken place may become red and swollen.

Every time the skin of your body is cut, the injured place should be kept clean. Wash it with soap and water so that no dirt can stay on the cut. Then put on something that will help to keep the cut from becoming poisoned. Usually you should wrap the cut with a piece of clean cloth so that no dirt can get in it.

If you could look at your skin through a magnifying-glass, you would find hundreds of tiny openings. These small openings, or pores, let the *perspiration* come out of the body. Perspiration is made up of materials that your body needs to get rid of. Your body cannot use some parts of the food you eat. It has to get rid of those parts just as a steam-engine has to get rid of ashes. Some of the useless materials come out of the body in the perspiration.

A bath with warm water and soap cleans your skin and washes off perspiration. Dust and dirt that fill the pores in the skin are washed away, too. If you want to keep your skin clean and healthy, you must wash it often.

Much of the perspiration soaks into the clothes next to your skin. So the clothes that you wear next to your skin should be changed often and washed in hot, soapy water.

* * *

Should people use more clean clothes in summer or in winter? Why?

What three things should you do if you cut your finger?

Why should you take baths often?

How does perspiration help the human machine?

How do you know what goes on around you?

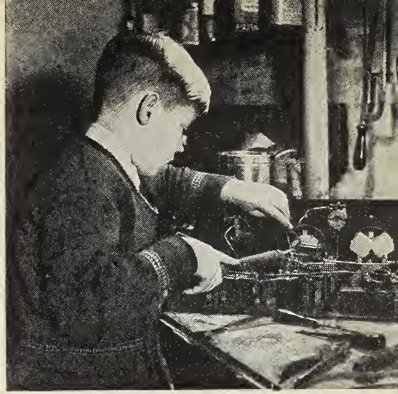
Your body has many parts whose work is to let you know what is going on around you. Let us see what some of these parts are.

How can the "blind man" catch someone and tell who it is?

You may not know it, but you have feelers on your body. They are not at all like those on a cat or on a grasshopper. Your feelers are tiny spots all over your skin. They help you in many ways.

Suppose you are hunting for your cap in a dark room. You cannot see, but you find your cap just the same. Probably you first feel along the walls. They feel hard when you touch them. Then your hands with their hundreds of feelers touch something else in the darkness. It is not your cap, because it is harder than a cap and feels smooth. It is your rain-coat. Then your hand strikes something sharp. You pull it back quickly because your feelers have been touched by the sharp end of a hook in the wall. At last your hand finds something that feels soft. You can tell that it is made of cloth, and you feel a hard round part on it. You are touching the button on your cap.

These feelers all over our bodies sometimes keep us from injury. If we touch a hot pan on the stove, we quickly jerk our hand away so that we are not badly burned. The feelers tell us when we are too cold, so that we can put on heavier clothes.



The radio that Jimmy is making is a sound-catcher. What other sound-catchers help him when he uses his radio?

Your ears are the sound-catchers that hear so many things that go on around you. They can catch the sound of the wind whispering through the trees, and they can catch the sound of a great explosion. They catch hundreds of different sounds every hour. Without these very important sound-catchers you could never hear what your friends have to tell you. They would talk to you, and you would only see their lips move. Think of the interesting and important things you would miss if you could not hear.

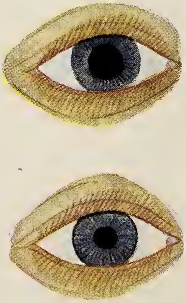
The outside of your ear catches these sounds, and they travel to the inside part of your ear. This inside part is very delicate. It is well protected by your skull, but things sometimes happen to harm it. A very loud sound may harm the inside of the ear. That is why you should never shout into anyone's ear. Putting anything that is sharp into your ear may hurt some of the ear parts.

To help you learn other things around you, you have two very good cameras. You are using them now as you read this page. Feel them carefully. Can you feel that they are round? Suppose you

How is Bobby using his eyes to help him play ball?

look at your eyes in a mirror. Do you see the very dark place in the center of each eye? This dark spot is the *pupil* of the eye. The pupils are like windows in your eyes. They let the light into the inside of your eyes. If these pupils did not let in the light, you could not see.

Sometimes when there is too much sunshine coming through the windows of your house, you pull the shades down. The pupils in your eyes have a way of closing, too. Very tiny muscles in your eyes make these little openings larger or smaller. On very bright days, or if you are reading in bright light, the muscles close the windows part way so that less light comes in. At night, or on dark days, the muscles open the windows of your eyes and let in more light.



Have you ever gone from the bright out-of-doors into a dark theater? Do you remember how dark it seemed at first? Then you began to see the people. In a few minutes you could see well enough to find a seat. The muscles that open and close the pupils in your eyes needed time to open the windows to let in more light. Inside the theater there was not much light; so the windows needed to be open wide.

Many people wear dark-colored glasses in summer when the sun is very bright. This keeps the bright light from striking the eyes. Too much bright light stretches the muscles that open and close the windows of the eye. After they have been badly stretched, they do not work well. That is why you should never look straight at the sun or any other bright light. Reading in bright sunshine hurts the eyes, too.

Inside your mouth are tiny parts that tell you about the food you eat. If it were not for these tasters, a piece of candy and a pickle would be the same to you because you could not taste either one.

Often your mother tastes milk to see if it is sweet. When you are cracking and eating nuts, you may find spoiled ones. Sometimes you cannot tell that a nut is spoiled by looking at it. But your tasters tell you in time so that you do not swallow it. In this way our tasters sometimes keep us from harm. When we taste food and find that it has spoiled, we do not swallow it. If such food gets into our stomachs, it may make us sick.

You can tell what is cooking on the stove in another way besides tasting it or looking at it.

Do you know how? You can smell it. If there is sweet corn cooking on the stove, some of the odor comes out into the room. You breathe the air through your nose, you smell the odor, and then you know what is cooking.

* * *

Name four parts of your body that help you to know what is going on around you.

What can you do to keep your eyes and ears from being harmed?

Explain how the windows in your eyes work.

How do the messages that come through your nose help you? Think of all the ways you can, such as helping you find things or helping you keep out of danger.

Tell how your eyes help you.

What keeps the parts of the body working together?

Every part of the body machine must be kept at work. The heart must keep pumping the blood. The muscles must keep moving the body. The lungs must do their work. Suppose your lungs took an hour's rest, or your heart stopped work at five o'clock in the afternoon! All the other parts would stop working, too, and you could not live.

The director of your body is the *brain*, inside your skull. All the other parts of your body do what the brain tells them to do. Every message that comes to your body goes to the brain first. Then your brain tells your body what to do about it.

The *nerves* are the message-carriers. They run to every part of the body machine. Thousands of them go to the skin, carrying messages back and forth between the skin, the brain, and other parts of your body.

You put your hand on a hot stove. At once the nerves carry the message of pain to the brain. The brain rushes back a message over the nerves to the muscles of your hand and arm, and you pull your hand away. Your eyes see an automobile coming toward you. Into your brain rushes the message. Down to your legs rushes another message, and you jump out of the way. Do you see that the nerves carry messages almost as telephone wires do?

Suppose you are watching a circus parade. How do you think the message-carriers work? It will be fun to see how they act while we watch a parade.

Listen! Do you hear the drums in the band? The parade is coming. The sound from the beating drums travels to your ears. Away goes the message of sound along the nerves to the brain. Do you hear the people talking and the sound of the peanut wagon's whistle, too? The nerves that carry sound messages in your body are certainly kept busy.

And that is not all. Your eyes are seeing things, too. Look at the red and white flags. See your friends. Now the band is coming, and the horns are shining in the sun. Are those elephants that are following the band, and is that a clown in the green coat? Hundreds of messages have been carried from your eyes to your brain in these few minutes.

Everything that you see and hear makes you want to be nearer to the parade so that you can see better. Your brain sends a message to your legs, and you walk or run to another place. While you are running, you fall and bump your head. Nerves carry a message of pain to your brain. Your brain sends a message to your hand, and you rub the hurt spot.

There are still other nerves at work. You smell pop-corn, see the pop-corn wagon, and buy a bag. As you eat it, you like the taste of it. Nerve messengers work so that you can do this. You say this must have been a very busy day for your brain and nerves. Every day is a busy day for them.

Probably you have wondered why the messages did not get mixed up when there were so many of them every minute. That is because there are two nerves running from your brain to each part of your body. One carries messages to the brain, and the other carries messages away from it. And the brain is the best director that ever told anyone what to do. It can do many things at once and not get mixed up.

* * *

How are the nerves in your body like telephone wires?

Try to remember what happened this morning as you walked to school. Tell how the message carriers of your body worked so that you knew what was happening as you walked along.

Questions to Think About

1. Tell how each of the following parts is important to your body:

Joints Muscles Brain Skin
Heart Skeleton Teeth Nerves

2. How can you tell when your body machine is not working well?

3. What are some of the things a doctor does to find out why you are sick?

4. What must happen to food before your body can use it?

5. What two things does the blood carry?

Things to Find Out

1. Make a list of things you can do to take care of your body machine.

2. Get a large bone from a meat-market. Study it to find out:
   - *a*) What the inside of it looks like.
   - *b*) How muscles are fastened to it.
   - *c*) How it is fastened to another bone.
   - *d*) How the blood gets inside the bone.

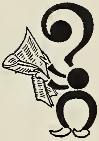
3. Ask a doctor or a nurse to come to your school and tell you:
   - *a*) How a boy or girl can keep from getting sick.
   - *b*) What things the body machine needs every day.
   - *c*) What they are trying to find out when they examine your body.

4. Ask another class to come to your room to hear some of the important things you have learned in this

unit. You may want to tell them about some of these things:

- *a*) Why is the body the most wonderful machine in the world?
- *b*) What happens inside of you when you eat?
- *c*) How do you know what goes on around you?

Reading the Newspaper



John saw this advertisement in the newspaper:

Take Grow-powder to make your bones strong and healthy. Grow-powder will make your muscles strong. It will make you win at games. It tastes like candy.

John was talking to his sister Betty about the advertisement. He said, "Why don't we ask Dad to send for some? It would be fun to take it."

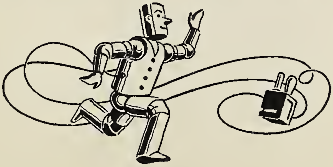
Betty said, "I'd never take any unless Dr. Miles said to. Anyway, I don't believe everything I read."

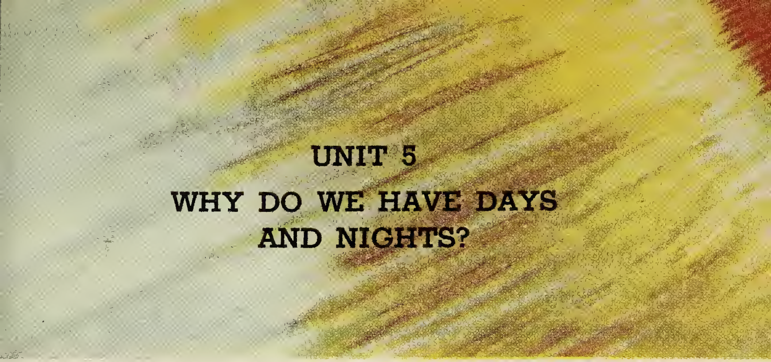
Was John a good science thinker? Was Betty?

Do you believe all of the advertisements in the newspaper? Why?

How can John and Betty grow strong muscles and bones?

Was Betty right when she said, "I'd never take any of the medicine unless Dr. Miles said to"? Why?





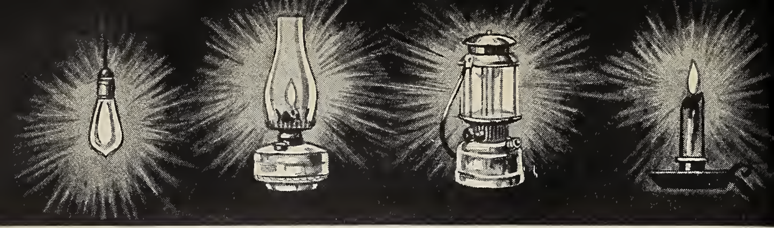
UNIT 5

WHY DO WE HAVE DAYS AND NIGHTS?

WOULD YOU believe that day comes because a sun-god rolls the sun into the sky? Would you believe that night comes because the god carries the sun away? Would you believe what a small boy once said about day and night? "I know what makes night," he said. "The sun goes into my neighbor's woods. That makes night."

Of course you know that night and day are not caused by a sun-god. And you know that the sun does not go into a woods at night. But do you know what really does cause day and night?

Thousands of years ago people began to wonder why darkness came at night and why light came again every morning. They watched the sun as it seemed to move across the sky. They studied the earth, too. But it took them hundreds of years of study and careful watching to find out what makes day and night. In this part of your book you will read some of the very important things that men have learned about the earth and the sun. These



Can you tell how all of these lights are alike?

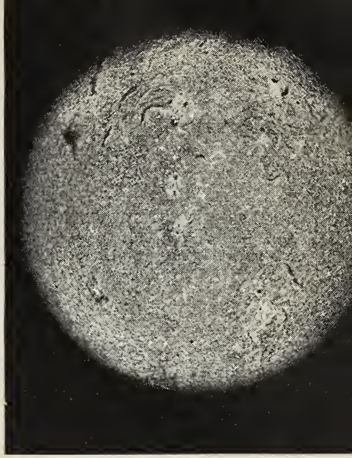
facts will help you to understand why we have daylight and darkness on the earth.

How does the earth get its light?

How many ways can you think of to light a room? What ways do you use in your home? You can use electric lights. You might use lamps that burn oil. You might use gas lamps, or you might light a room with candles.

All of these lights are alike in one way. Do you know how they are alike? They are all very hot. The electric light bulb is hot; so you can be sure that the thin, glowing wires inside must be hot, too. The wire in the electric light bulb gets so hot that it glows and lights the room. The burning oil in the wick of the lamp gets so hot that it gives off light. Almost anything will give off light if it gets hot enough. Have you ever seen iron so hot that it glowed with a red or white light?

Now if someone asked you this question, what would you answer? "Why does the sun give light?" A good answer would be, "The sun gives off light because it is hot."



This picture of the sun was taken through a telescope.

The sun that warms us and gives us light is a great ball of very, very hot gases. Nothing on earth is so hot as the sun. The outside of this glowing ball is about one hundred times as hot as the hottest day on earth. The inside of the ball is thousands of times as hot as any fire you could make!

In the morning you see this great red or yellow ball in the eastern sky. During the morning you see it higher and higher in the sky. Then it begins to sink toward the west, until at last it has gone from sight. After sunset, darkness soon comes.

This yellow ball of glowing hot gases does not seem very large. As we look at it up in the sky, it seems to be about as big as a bicycle wheel. You would probably guess that it was much smaller than the earth we live on. But the sun is really not small. It is more than a million times as large as the earth! It looks small because it is so far away. Looking at the sun is like watching an airplane in the sky. When the airplane is far up in the sky, it looks very small. As it comes closer, it looks larger. A house or a ship or a tree or an

Boats and buildings seem large when they are close to you. But how tiny they look when they are far away!

automobile looks small when it is far away. The sun looks small because it is millions of miles away from us.

You can understand how large the sun is if you make two drawings on the blackboard. Draw a circle the size of a pea on the board. Next to it make another circle thirty inches across. Label the small circle "The Earth." Label the large one "The Sun." Now you have a picture that helps you to see how big the sun is.

It is a good thing that our earth does not move any nearer to the sun. If it did, we would all be baked by the heat. But do not worry. The sun and the earth will not get any closer together than they are, and the sun will go on lighting and warming the earth for us.

Now you know that the sun is the earth's lamp. We might call it a great gas light. Half the time it lights the place where you live, and half the time it leaves you in darkness. The light times we call *day*, and the dark times we call *night*. Do you know why we are lighted by the sun part of the time and why we are left in darkness part of the time? Where does the sun go at night? Or is it the earth that goes somewhere?

Before you can answer any of these questions, you need to know some very important things about the earth. First, you need to know the shape of the earth.

* * *

What is the sun made of?

What is the shape of the sun?

The sun is much larger than the earth. Why does it look so small?

Why do we sometimes call the sun the earth's lamp?

What is the shape of the earth?

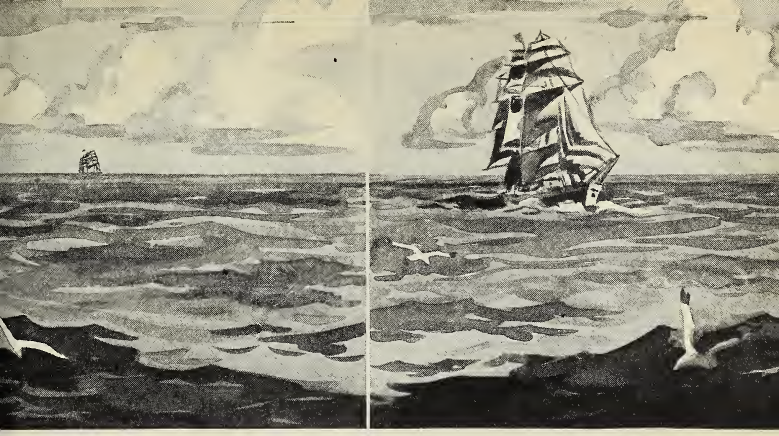
Do you know the shape of this earth you live on? You probably have heard that it is shaped like a ball. It is hard to think that we are walking around on a ball, isn't it? But that is just what we are doing, for the earth is a big ball.

Perhaps you wonder why the earth does not seem round as you look out across the fields. The earth does not look round because it is so very large. You can look miles away, and you cannot tell that the earth curves at all. You cannot see enough of the earth to tell that it curves.

It is not surprising that hundreds of years ago people thought the earth was flat like a table. They did not know as much about the earth as you will know when you have studied this book. They were sure that if they went far enough, they would come to the end of the earth. They were afraid to travel very far out on the ocean. They thought that the ship would come to the edge of the earth and fall off!

As people learned more and more about the earth, they began to wonder if it really was flat. About 450 years ago a very wise man became quite sure that the earth was shaped like a ball. Most people just laughed at him. They would not believe anything unless they could see it. And of course the earth looked flat to them, just as it does to us.

But a few thoughtful men tried to solve this puzzling problem of the earth's shape. They could not get far enough away from the earth to see its shape. What do you think helped them to find out the real shape of the earth?



What do you see in this picture that can help you prove that the earth is round?

In the days of long ago, people did not do much traveling. Whenever a ship came back from sea, great crowds gathered at the shore to watch it. Some of the thoughtful men who watched the ships come in noticed something strange. They noticed that when the ship was far out, they could see only the top of the sails. As the ship came nearer, they could see the lower part of the sails. As the ship came still closer, they could see the body of the ship.

This made them feel sure that the earth must be shaped like a ball. For if the earth were flat, all of the ship could be seen in the distance at the same time. It would just look bigger as it came nearer. Study the picture on this page. Do you think these men were right?

If you do this experiment, you can understand how watching ships come in helped men prove that the earth is a big ball. Have someone hold a tiny boat on a globe, as you see in the picture. The boat should be on the opposite side of the globe from you, so that you cannot see it. Then have the boat moved slowly around the globe toward you. Which part of the boat do you see first? Do the experiment again and watch closely. Name the parts of the boat as you see them.

Now take the boat from the globe and put it at one end of a long table. Think of this table as a flat earth. Go to the other end of the table and stoop down until your eye is on a level with the table top. Watch the boat as someone moves it toward you. Do you see first just the top of it,

or do you see all parts of it at the same time? This experiment shows you that if the earth were flat, you would see all parts of a ship at the same time. Because the earth is round, you can see only the top of the sails or the smoke from the smoke-stack as a ship comes toward you.

Christopher Columbus was one of the first sailors who believed that the earth was shaped like a ball. He believed that he could sail around it, and he tried to do so. But he landed in America and went back home to tell about his discovery. Since the time of Columbus thousands of persons have traveled around the earth. Aviators have flown around it in a few days.

* * *

Tell two things to prove that the earth is a big ball.

Why do you think it took people so many years to find out that the earth is round like a ball?

Explain how watching a ship helped people find out that the earth is shaped like a ball.

How does the earth move?

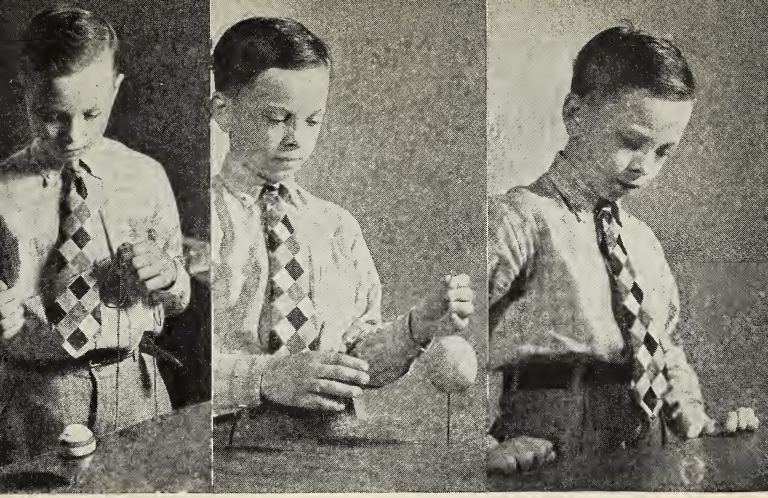
Now you have learned that the earth is a ball and that the sun gives it light. There are still other things to learn about the earth before you can understand what makes day and night.

The sun shines on the earth all of the time. But you know that the earth is dark part of the time at the place where you live. Can you tell what makes these days and nights on the earth?

People wondered about this for a long time. They knew that either the sun or the earth moved. For thousands of years they believed that the sun moved, because they could see it in different places in the sky. But some of the wise, thoughtful men began to wonder. They not only looked carefully at things, but they thought about the things they saw. They wondered if it was not the earth, instead of the sun, that was moving.

At last one of these wise and thoughtful men was able to prove that the earth spins around like a top. You can understand how the earth turns if you watch a top that is spinning. Turn a globe around fast and watch it spin, too. The top, the globe, and the earth all turn around on an *axis*.

You can understand what "turning on an axis" means if you try this experiment with an orange. Roll the orange on your desk. Do you see that it turns this way and that way? Now push a short,



How are the top, the orange, and the coin alike?

stiff piece of wire through the orange and whirl the orange around on the wire. This time the orange does not turn in different directions. It keeps spinning around in the same way. It spins around on the piece of wire. That is what we mean when we say that something is turning on an axis.

Now take a quarter or some other coin, hold it on edge, and snap it with your finger so that it will whirl on the table. Do you see that it turns just as the orange did, except that there is no wire through the coin? The coin is turning on its axis, too. Can you imagine that there is a line running through the coin like the wire running through the orange? The axis of the coin is an imaginary line around which the coin spins.

We say that the earth turns on an axis, too. It keeps spinning around in the same direction, just as the quarter did. There is no rod running through the earth. When we speak of the *earth's axis*, we mean an imaginary line through the earth. The ends of this line are called *poles*. One end is called the North Pole of the earth, and the other is called the South Pole. Of course there are no poles sticking out of the earth. Wherever you are on the earth, the direction north is toward the North Pole; south is toward the South Pole.

Why do we have daylight and darkness?

Now you have learned three very important things to help you understand why we have darkness and daylight.

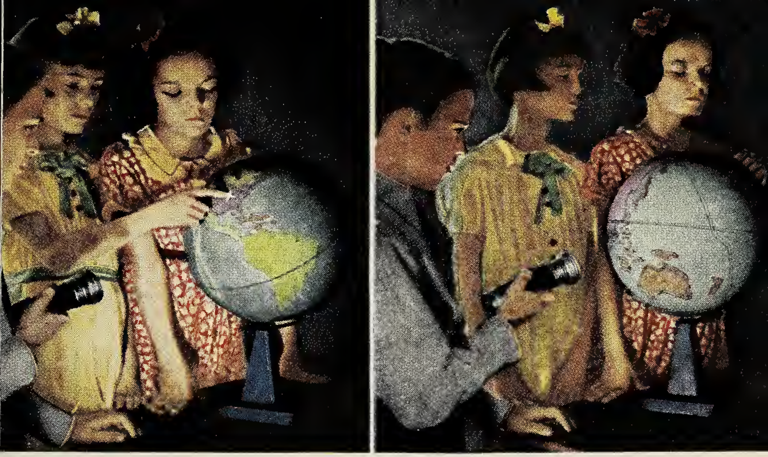
First, you know that the sun lights the earth.

Second, you have learned that the earth is shaped like a ball.

Third, you have found that the earth spins around like a top.

A top spins around in a flash. The earth, too, spins very fast. But the earth is so big that it takes twenty-four hours to turn around once.

Now, if you will do this experiment, you will understand why we have day and night once every twenty-four hours. You need a globe to use for the earth and a flash-light or some other light to use for



In the picture at the left, Betty is pointing to her home on the globe. It is day-time at her home. What has happened in the second picture?

the sun. Now darken the room and hold the flash-light near the globe. Look at the globe. Is only part of it lighted? How much of it is lighted?

Remember that the flash-light is the sun and that the globe is the earth. Place a large chalk mark on the globe near where you live on the earth. Turn the globe all the way around once on its axis. Do this slowly. What happens to the place where you live? Is it lighted for part of the time and then dark for part of the time? When the chalk mark is lighted, you are having day. When it is dark, you are having night.

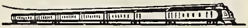
This experiment shows that during one turn of the earth, the place where you live is light part of the time and is dark part of the time. When the part of the earth where you live faces the sun, you have day. When it faces away from the sun, you have night. You remember that the earth spins around once in twenty-four hours. So during every twenty-four hours we have daytime and night-time.

Turn the globe so that the place where you live will be having night. Now turn the globe slowly to show where your home will be when you are getting up in the morning. Turn it farther until it shows noon at your home. Keep turning the globe to show where your home is when school is out in the afternoon. Now move it to show that it is almost night.

In this experiment which did you move, the globe or the light? You moved the globe; the light did not move. So it is with the earth and sun. The sun does not travel across the sky. The earth is turning on its axis; that is what makes the sun seem to pass across the sky. We first see the sun in the east in the morning. By noon the earth has turned more, and we see the sun over-head. By evening the earth has turned still more, and we see the sun low in the west. At last we cannot see the sun at all, and night has come.

It took people many years of study to find out that the earth is spinning around like a top. For a long time it seemed to them that the sun must surely be moving across the sky. Sometimes it is even hard for you to tell whether you are moving past some object or whether the object is moving past you. Have you ever been on a train and said to yourself, "Is my train moving, or is it the train on the other track?" If your train starts smoothly so that you cannot feel it move, the train on the next track seems to be moving.

You can easily see why it took people a long time to find out that the earth is a spinning ball. You can also see why it was hard for them to believe that the sun does not move across the sky. But wise men, who watched things carefully, proved to every one that the spinning of the earth makes day and night.

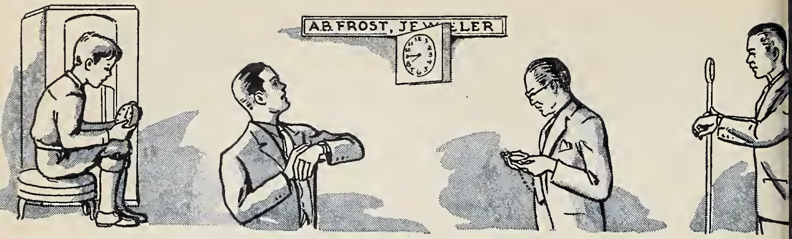


Which of these facts do you need to know to explain why we have day and night?

a) Sometimes the clouds hide the sun.
b) The earth spins on its axis.
c) The earth gets its light from the sun.
d) The earth is round like a ball.
e) Some nights are very dark.

How much of the earth is lighted all the time, half of it or all of it?

How many times does the earth turn on its axis in one school week?



How is the earth a clock?

The earth is the largest clock you have ever seen, and it is always on time. Does this idea puzzle you? Probably you have thought that a clock is a piece of machinery that tells us what time it is. You are right. A clock is a machine that tells us the time of day or night. All day and all night the hands of the clock turn slowly around, pointing first to one number and then to the next. We say that it is one o'clock, or two o'clock, and so on.

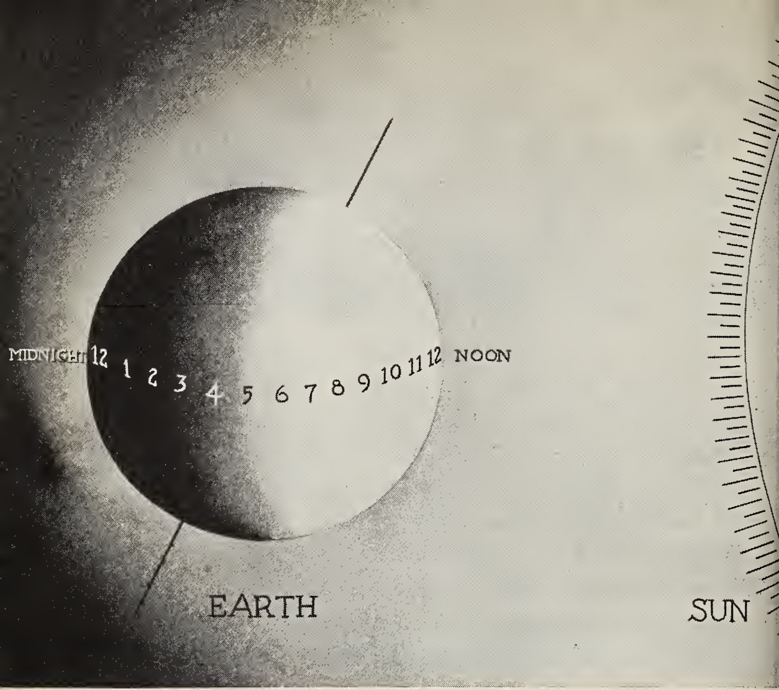
But what do you mean when you say that it is one o'clock or two o'clock? Suppose your clocks at home are wrong. Then how do you find out what the right time is? Perhaps you listen to the radio to find the right time. Or maybe your father says, "My watch is right. I set it by the clock in the jewelry store this morning." But how do the radio man and the jeweler find out what the right time is?

If you are on an all-day hike and do not have a watch with you, is there any way you can tell about what time it is? Probably you would look at the sun. If the sun is almost overhead, you say, "It is just about noon. Let's eat our lunch." If the sun is low in the west, you say, "It must be late in the afternoon. The sun is almost down."

That is the way men and women used to tell time long ago before clocks were made. They used the sun as a clock. You really tell time that way yourself! When you look at the clock, the clock is really telling you where the sun is. Now let us see why that is true.

When the earth has made one turn around on its axis, we say that a day has passed. We divide the day into twenty-four equal parts, called *hours.* When the earth has gone half-way around, we say that twelve hours have passed. But how can we tell how far the earth has turned? We cannot see it turn unless we watch something that we pass.

If you shut your eyes on a merry-go-round, you cannot tell how far you have turned or how many times you have turned around. But if a friend of yours is standing beside the merry-go-round, you can look at him and count the times you pass him. Then you know how many times you have gone around. If you watch your friend, you can also tell when you have gone half-way around.



Do you know what we watch to tell us how far the earth has turned? We watch the sun. It tells us when our earth has turned around once. It also tells us how far the earth has turned at any time.

Every day in the city of Washington a man finds out the right time and sends it to every part of our country. He points a huge telescope toward the sky in a straight line north and south. When the earth has turned so that the sun is at the highest place in the sky, he sends signals over the country to let people know that it is noon. It is twelve o'clock in the city of Washington. People can set their clocks then. The radio man can get the right time. So can the jeweler.

When you look at your clock and see that it is twelve o'clock noon, you are really finding the time when the sun is highest in the sky. At three o'clock in the afternoon you know that it is three hours past the time when the sun was highest in the sky. You know that it will take twenty-four hours for the earth to turn until the sun is at the same point in the sky again.

Do you see how the earth is our clock? Your clock at home may run too fast or too slow. But the earth keeps turning, turning at the same speed year after year. It turns around once every twenty-four hours.

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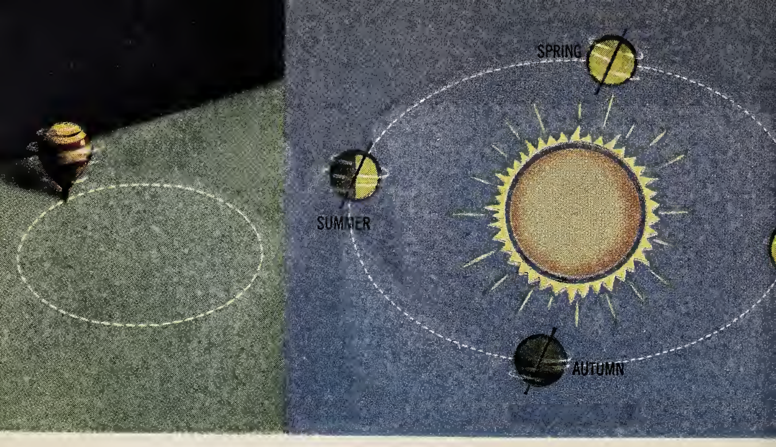
How far around has the earth turned at midnight?

How do you think the Indians knew when it was noon?

How many times has the earth turned on its axis since yesterday at this time? How many hours have passed?

Is the earth ever late, or is it always on time?



What makes a year?

You have learned what makes a day. You remember that it is the time it takes the earth to spin once on its axis. But you do not measure your age in days. How do you measure how old you are? You measure your age in years. And years are measured by another way in which the earth moves.

Look at the picture on this page. Does it show you that the earth is doing something else besides spinning like a top? It is swinging around the sun all the time, just as you swing around the center of a merry-go-round. Did you ever spin a top? Sometimes a spinning top will move slowly around almost in a circle while it is spinning. Study the picture on this page. Can you see that the top and the earth are both making the same two kinds of movements?

You remember that it takes twenty-four hours for the earth to spin around once on its axis. But it takes 365 days for it to swing all the way around the sun. We call the time it takes the earth to swing around the sun a *year*. This means that if you are ten years old, the earth has traveled around the sun ten times since you were born. If anyone asked you how you measure your age, a good answer would be, "I get a year older every time the earth travels around the sun."

Look again at the picture on page 164. Do you see the names of the four *seasons* of the year? Suppose that the earth begins its trip around the sun in January. When summer comes, has the earth traveled half-way around the sun, three quarters of the way, or one quarter of the way? How far has it traveled when spring comes?

Do you see that in summer the earth is on the opposite side of the sun from where it was in winter? When is it on the opposite side from where it was in autumn? The seasons tell us how far the earth has traveled around the sun since the year began.

* * *

What two movements does the earth make?
Which movement gives us our days?
Which movement gives us our years?
Into what four parts is the year divided?

How do the days change in length?

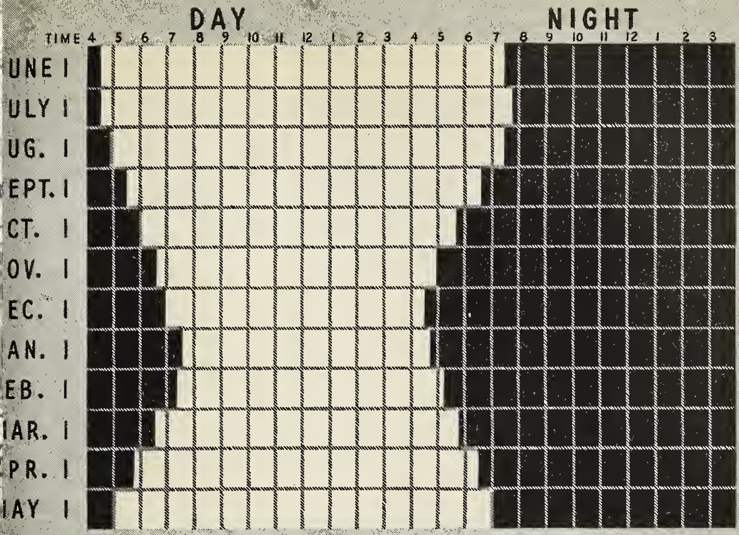
Have you ever read this little poem? What does it tell you about the days during the year?

In winter I get up at night
And dress by yellow candle-light.
In summer, quite the other way,
I have to go to bed by day.

Of course you have noticed that some days are much longer than others. Summer days are long. The sun is up long before you get out of bed, and after supper it still gives light enough for you to play out-of-doors. You can still see well enough to play a game of ball at seven o'clock on summer evenings.

Winter days are short days. The sun does not rise until you are having breakfast, and it goes down before you eat your supper. You do not play out-of-doors after supper. You stay indoors and read or play games.

You can find out just how much the days change in length by keeping a record of the hours of light and dark. The length of daylight is from the time we first see the sun in the morning until we no longer see it in the west. It will be hard for you to tell the exact time of sunrise every morning. You probably do not get up early enough. And clouds often hide the sun. But the time of sunrise and sunset is printed in the newspapers.



Here is a record of the length of the days that some boys and girls once made. You see that there are twenty-four squares in each row across the chart. Each square is an hour of time. The white squares show the number of daylight hours. The black squares show the number of hours of night. The date beside each row of squares shows what time of the year it was.

* * *

Which months have the longest days?
Which months have the shortest days?
Is your birthday on a long day or a short day?

Why are summer days warmer than winter days?

Summer days are longer than winter days. They are different in another way, too. Summer days are much warmer than winter days. Can you think of one reason why this is true? You know that the sun gives us heat and light. So the longer the sun shines on the earth, the longer we get heat from the sun. The days are longest in summer; so in summer we get the most heat.

In winter the days are short, and the nights are long. The sun does not shine on us for so many hours. The earth gets less heat from the sun, and the days and nights are cold.

There is another reason why the days are warmer in summer and colder in winter. It is because of the way the sun shines on the earth. You know that the sun is not always in the same position in the sky. In summer it is higher in the sky and shines almost straight down on the earth.

You know that the day is usually hotter at noon than it is in the morning or in the evening. You also know that the sun is highest overhead and shines almost straight down at noon. Do you see that the sun gives most heat to the earth when the sun is straightest overhead?

The sun is straightest overhead during the summer days. The earth gets the most heat when the sun

This picture shows what a long shadow is made when the sun is low in the sky.

is straightest overhead and when it shines the longest. So the days are warmer in summer than they are during the other seasons of the year.

There is an easy way to show that the sun is higher in the sky at noon in summer than it is in winter. You know that when the light strikes you, your body makes a shadow. You can measure the length of your shadow at noon in summer and in winter. Then you can tell when the sun is highest in the sky.

If you have ever watched your shadow as you walked under a street light at night, you understand how the length of a shadow changes. When the light is straight over your head, your shadow is short. If you walk away, so that the light is not over your head, the shadow gets longer.

You can show how shadows change in your school-room by using a light for the sun and a yardstick to make the shadow. First hold the light nearly above the yardstick. Is the shadow long or short? Next move the light to one side of the yardstick. Does the shadow get longer?

* * *

Tell two reasons why summer days are warmer than winter days.

How does your shadow tell you when the sun is straightest overhead?

Questions to Think About

1. Why have people changed their minds about what makes day and night?

2. Which of these things did people need to know before they could understand what makes day and night?

a) The earth is round.
b) The sun is far away from the earth.
c) The sun gives light to the earth.
d) The earth turns on its axis.
e) Summer days are warmer than winter days.
f) The earth travels around the sun.

3. How does the change in the lengths of day and night make a difference to baseball players, farmers, drivers of milk wagons, and boys carrying newspapers?

4. Suppose the earth stopped spinning on its axis, but kept on traveling around the sun. How long would the days and nights be? Perhaps you can think up an experiment to help answer this question.

5. Why is it important for the men who run trains on railroads to know exactly what time it is?

Things to Find Out

1. Ask your jeweler how he finds out the correct time.

2. Lay a sheet of paper where the sun will shine on it all day. Have the long way of the paper point north and south. Stick a pin straight up and down in the paper at the south edge. Draw a line right on the shadow. Keep on drawing lines over the shadow every hour. How does the length of the shadow change? Could you tell time in this way?

3. Measure the length of your shadow when you come to school, after you have eaten lunch, and again when you are ready to go home. Why are the shadows different in length?

4. Find out how people learned to tell time before they had clocks.

5. When is the longest day of the year? When is the shortest day?

6. Find out what two days in the year are exactly the same length.

UNIT 6

WHAT HEAVENLY BODIES CAN WE SEE AT NIGHT?

Have you ever seen a sun at night? Of course you have. You have seen hundreds of them. You have seen so many suns at night that it would take you a long time to count them. Does this seem strange to you?

What is a star?

In the daytime you see only one sun. It is the great hot ball that gives us heat and light. But at night you look up into the sky and see hundreds of shining, twinkling suns. You have always called them stars, and they are stars. But they are suns, too. Each star is a big ball of gas. The gases are very, very hot, just like the gases in our sun. They give light, just as the hot gases in our sun do. It is this light that you see up in the starry sky.

Perhaps you wonder why these star suns do not look like our sun. It is because they are so far away. They are hundreds and thousands of times as far away from the earth as our sun is. You know that automobile lights look like tiny dots

You would see something like this if you looked at the sky through a telescope.

when they are a long way down the street. As they come closer, they look larger. If these far-off stars should come closer, they would look larger, too. Many of them are much larger than our sun. Some of them would cover the whole sky if they were as close to us as our sun is! If our sun were as far away as some of the other stars, it would look like a tiny point of light.

If someone asked you to draw a picture of a star, you probably would make a pointed one. Of course stars are really not pointed. They are big, round balls, just as our sun is. Stars look as if they had points because they are so far away. Street lights look as if they had points, too, when you see them far down the street.

Why do the stars have different colors?

Have you ever noticed that the stars are not all the same color? Some are bluish-white, some are yellow, and some are red. Do you know why this is so? If you try this experiment, you will be able to explain why the colors are different.

Find an old steel knitting needle or a piece of iron wire about a foot long. Hold the iron in a very hot flame. Keep it in the flame and watch the color of the iron change.

Why has the end of the knitting needle changed color?

Before you put the wire into the flame, the iron is cold. It does not give off any light or heat. Soon after you put it into the fire, it begins to get red hot. It gives off a red light. As you keep heating the iron, it gets hotter and hotter, until it is yellow. When the iron is yellow, it is hotter than it was when it gave the red light.

If you could heat the iron still hotter, it would get so hot that it would give off a white light. It would then be very, very hot.

Now do you see why there are different-colored stars? And can you tell the hottest star from stars that are not quite so hot?

You know from your experiment with the iron that red stars are hot, but they are not so hot as some of the others. Have you found yellow stars in the night sky? They are hotter than the red stars. There are other stars in the heavens that give white light. From your experiment you know that they are hotter than either the red or the yellow stars.

Perhaps tonight you may look up at the sky and see a star that is bluish-white in color. You will probably say to yourself, "That is a very, very hot star. It is hotter than the yellow ones, and much hotter than the red ones."

* * *

How is our sun like the other stars?

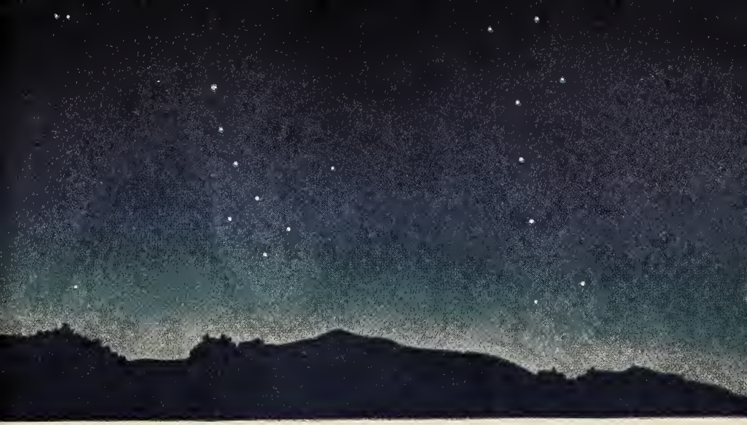
Is the star that we call our sun as hot as a bluish-white star? Is it as hot as a red star?

Why does the sun give light?

Some of the stars are larger than our sun. Why do they look smaller than the sun when we see them at night?

What is a constellation?

Suppose you go out-of-doors tonight and look at the stars. Soon after the sun goes down, they begin to come out. At first you see only a few stars. As it grows darker, you see more and more of them. At last the whole sky seems to be filled with hundreds of shining points.



Look closely, and you may see that some of these stars are grouped together. One of these groups of stars makes a picture of a huge dipper. You will be able to find it easily if you face toward the north and look up at the sky. You will see the bowl of the dipper and the long, curved handle. This picture of a dipper is one of the easiest groups of stars to find.

Look near this dipper in the northern sky, and you may see a group of stars that make a smaller dipper. Can you see the two dippers in the picture at the top of the page?

We say that these star groups are *constellations* of stars. These constellations, or groups of stars, have names. The group that looks like a huge dipper is called the *Big Dipper*. It is part of a larger constellation, or group of stars, called *Ursa Major*. Ursa Major means "Big Bear."

The group that looks like a small dipper is called the *Little Dipper*. This group of stars is part of a larger group called *Ursa Minor*, which means "Little Bear."

You probably wonder why a group of stars is called Ursa Major, or Big Bear. For hundreds of years people have watched the stars and studied the constellations. The shepherds of long ago discovered these star groups as they watched over their sheep on the hillsides. The sky was about the only thing the shepherds had to look at through the long nights. They wondered what the stars were and how so many of them came to be up in the sky.

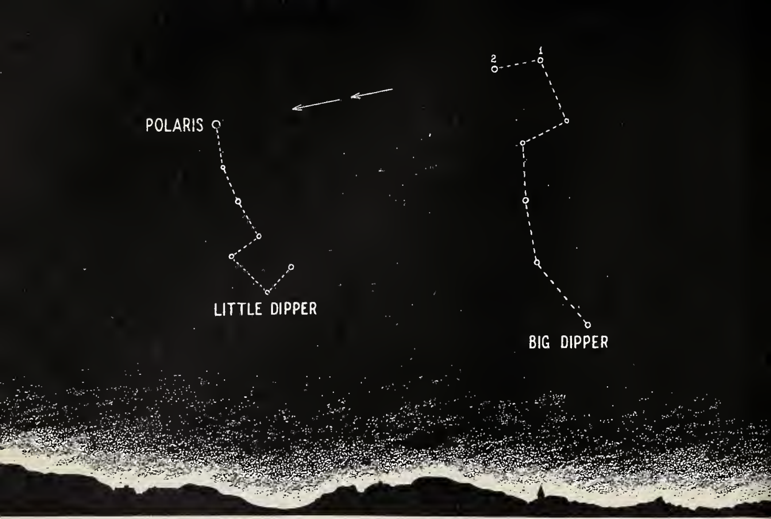
The shepherds made up stories about these constellations as they watched the starry sky night after night. They imagined that some of the groups of stars made pictures of animals. They thought other groups made pictures of kings or queens or hunters. Many other people, such as the Indians, made up stories about these groups of stars, too. The stories of the constellations are very, very old. Today we know that they are not true, but once people believed them. We still use the names that these people of long ago gave to the star groups.

The story about the constellation of Ursa Major is one of the most interesting of all star stories.

It tells of a princess who once lived on the earth, and of Jupiter, the king of the gods, who lived in the sky. The queen of the gods became very angry with the princess; so she had the princess changed into a bear.

One day when the son of the princess was hunting, he came upon this bear in the woods. The prince did not know that the bear was his mother. He was just going to kill the bear when Jupiter, king of the gods, stopped him. Then Jupiter changed the young man into a little bear, took him by the tail, and swung him into the sky. After that, Jupiter took the big bear and swung her up into the sky near her son.

Now you can understand why this constellation is called Ursa Major, or Big Bear, and why the Little Dipper is often called Ursa Minor, or Little Bear. *Ursa* is an old, old word for bear. *Major* means large, and *minor* means small. Do you see that the handle of the Big Dipper makes the tail of the big bear? What part of the Little Dipper makes the tail of the little bear?



This picture will help you to find the Big Dipper, the Little Dipper, and Polaris. It shows where they are at about eight o'clock in the evening in March. Of course, you face toward the north to find these stars.

There are seven bright stars in the group called the Big Dipper. In February and March you will find the Big Dipper standing on its handle in the northeastern sky. Four bright stars make the bowl of the Dipper, and three stars make the handle of the Dipper.

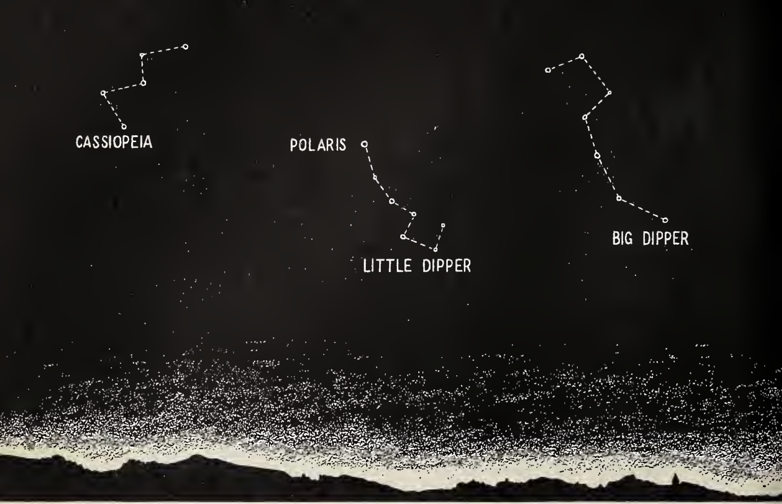
Look at the picture above and find the stars at the front of the bowl, numbered 1 and 2. These stars are very important stars to know. They will help you tell which direction is north, and they will also help you find other constellations. They are called the *pointers*. If you draw a line from 1 to 2 and follow the line on across the sky, you will see that it points toward one star. This star is called the *North Star.* Study the picture so that you can understand how to find the North Star.

Sometimes the North Star is called the *Pole Star.* When you look toward this star, you are looking north. It is called the North Star because it is always in the north. It is called the Pole Star because it is over the earth's North Pole. Another name for it is *Polaris.*

The constellation of the Little Dipper is easy to find if you have learned to find Polaris. Polaris is the end of the handle of the Little Dipper. Study the picture and see how easy it is to find the Little Dipper after you have found Polaris. There are seven stars in the Little Dipper, just as there are in the Big Dipper. But they are not nearly as bright as the stars in the Big Dipper. The Little Dipper, you remember, is part of a constellation called Ursa Minor.

Find the Big Dipper in the picture on page 177. Find Polaris and the Little Dipper. Find them in the picture on page 172. On a clear night you can find them in the sky just as you have found them in the pictures.

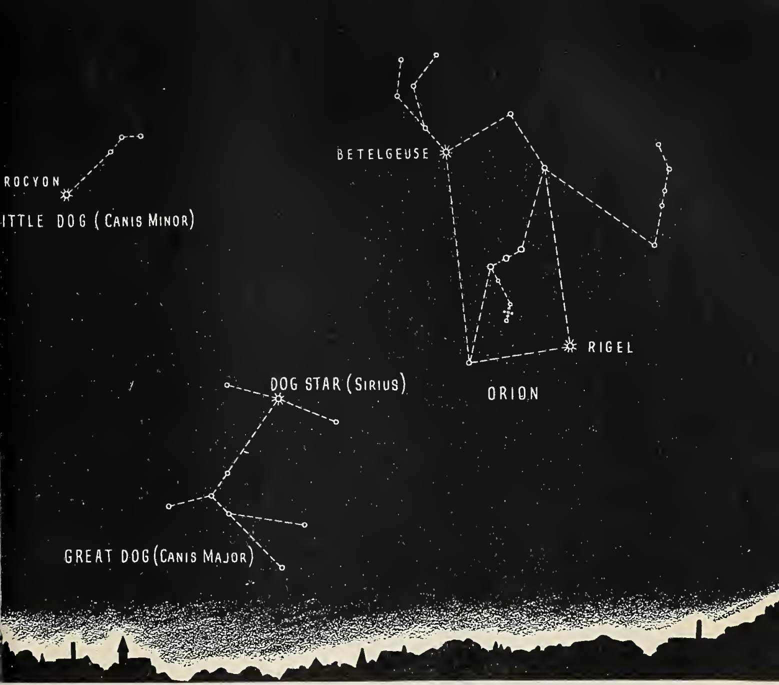
After you have learned to find the Big Dipper and the Little Dipper, you will want to find other star groups. Another constellation that is easy to



The picture will help you to find Cassiopeia. It shows where the constellations are at eight o'clock during the month of March. Face north.

find is the group of stars that looks like a W. The W is made of five bright stars. It is called *Cassiopeia*, the name of a queen of long ago. In the picture you will see that the letter W makes a throne for the queen. Find Cassiopeia in the picture on page 172.

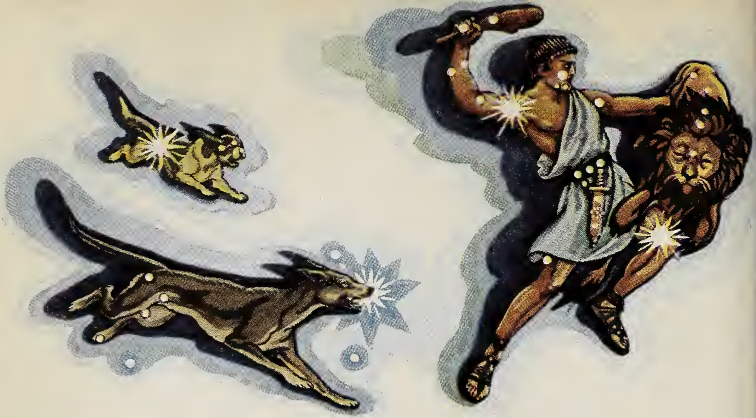
So far we have looked only at the stars toward the north. Now we will turn around and see what we can find in the southern part of the sky. Here



You can find these constellations in the sky if you face toward the south in winter.

we find a constellation that has some of the brightest stars in the sky. Its name is *Orion.*

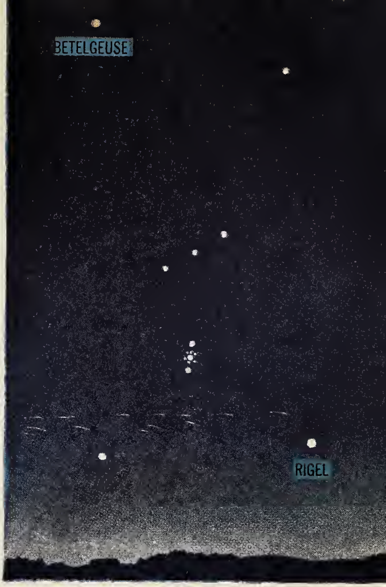
Long ago men thought that this group of stars made a picture of a mighty hunter. They named it Orion after a famous hunter in their stories. They imagined that the hunter in the sky had a belt with a shining sword hanging from it. In his right hand they thought he held up a big club. On his left arm he held a lion's skin for a shield.



Behind the hunter were his two dogs. In the picture on page 183 can you find the two constellations that make the dogs? What are the names of the constellations? What is the name of the brightest star in each constellation?

Orion is a large constellation, with more bright stars than any other constellation. To find Orion, look toward the southwest in March until you see three bright stars in a row. These stars are Orion's belt. Find them in the picture. Just below them are a few small stars close together. They show where the sword hangs from the hunter's belt. Below the belt and a little to the right is a large, bright star. This star is called *Rigel*, and it shows the lifted knee of Orion. There are only six stars in the sky that are brighter than Rigel.

Now look above the belt and a little to the left, and you will see another large, bright star. This



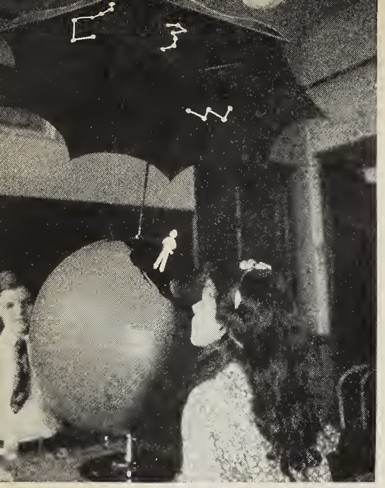
one is called *Betelgeuse*, and it marks Orion's shoulder. Betelgeuse is a very big star. It is many, many times as large as our sun. If Betelgeuse were as near to us as the sun is, it would cover the sky! It is a good thing that Betelgeuse is very far away from the earth. It would burn us up if it were as close as the sun.

You can be sure that you have found Betelgeuse and Rigel if you will notice their color. Rigel is bluish-white, while Betelgeuse is red. Can you tell which of these stars is hotter?

Why do we see the constellations in different places in the sky?

On some clear night, as soon as the stars are out, notice just where Orion is in the sky. Then just before you go to bed look at this constellation again. Was Orion farther toward the west the second time you saw it? If you stayed up much later to see Orion, it would be out of sight!

It is just the same as when you are watching the sun. You know that we first see the sun in the

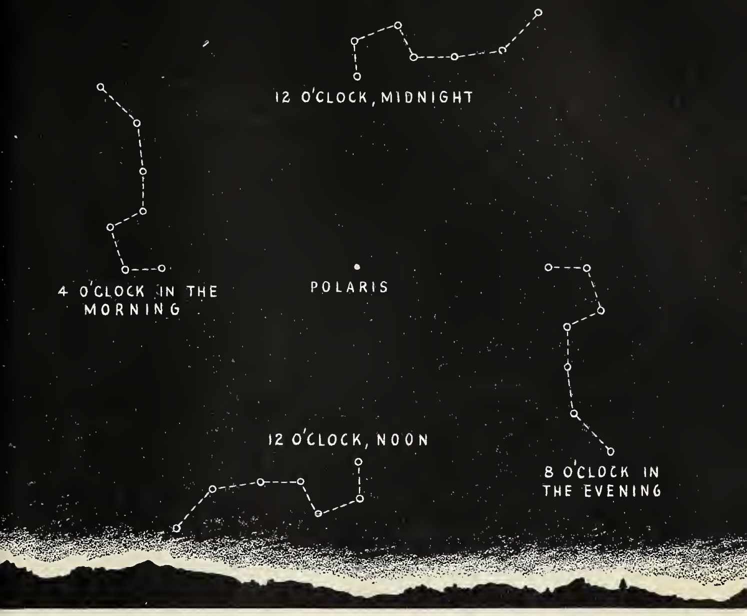


east, and at the close of day we see it disappear in the west. But the sun does not move around the earth, nor do the stars. We see the star groups in different places because our earth whirls on its axis through the night.

You can see why this is true if you will do an experiment like the one in the picture. On the under side of a black umbrella paint the Big Dipper, Little Dipper, and Cassiopeia. Fasten the handle of the umbrella to the globe at the North Pole so that the globe will turn but the umbrella will not turn. Be sure that the umbrella slants in the same direction as the axis of the earth. Then cut out a little cardboard boy and paste it on the globe near the place where you live.

Now stand beside the globe where the cardboard boy is pasted and look up at the umbrella sky. Is the Big Dipper at the right or at the left of Polaris? Turn the globe slowly about half-way around and follow the cardboard boy. Now is the Big Dipper at the right or at the left of Polaris?

This experiment shows that we see the stars in different places in the sky because the earth is



The Big Dipper may be used as a clock. It seems to move around Polaris like an hour-hand on a clock. Long ago people told the time of night by the Big Dipper.

turning on its axis. You remember that the North Pole of the earth always points toward the North Star. That is the reason Polaris is the only star in the sky that seems to stay in the same place.

* * *

Name four constellations and tell how you would help someone find them.

Draw the Big Dipper and show how to find Polaris by using the pointers.

How is the moon different from the stars?

While you have been watching the stars, you have surely noticed something else in the sky. It gives us more light than anything in the sky except our sun. It is, of course, the *moon*. The moon is nearer to us than any of the stars. It is only about 250,000 miles from us, while the sun is millions of miles away. The moon is solid, like the earth, and round like a ball.

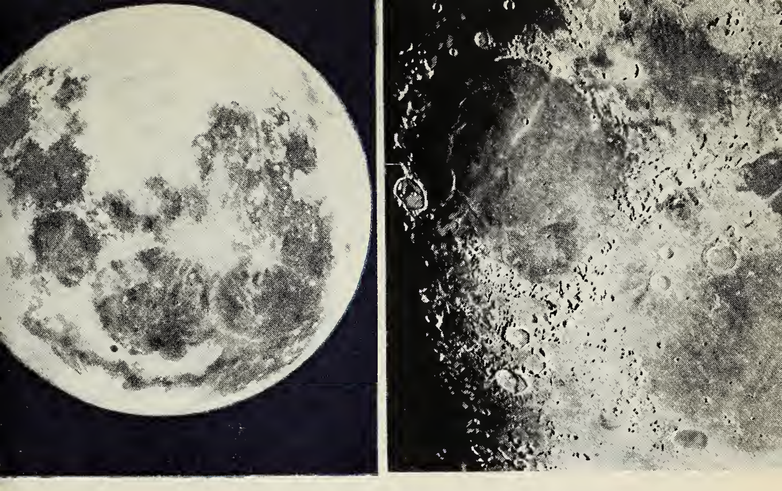
The moon is not hot like the sun and the stars; so it cannot give its own light. How do you think we can see it, then, if it does not give light?

Have you ever ridden along a country road at night and noticed the signs that shine when your automobile lights strike them? The word "Stop" or "Curve" is often made with little pieces of glass. At night the lights from your car shine on the signs, and they glow as if they were electric lights.

The signs have no lights of their own. We say that they *reflect* light from the automobile. *Reflect* means to throw back the light. The moon gives us light in the same way. Light from the sun strikes the moon, and the moon reflects the light.

* * *

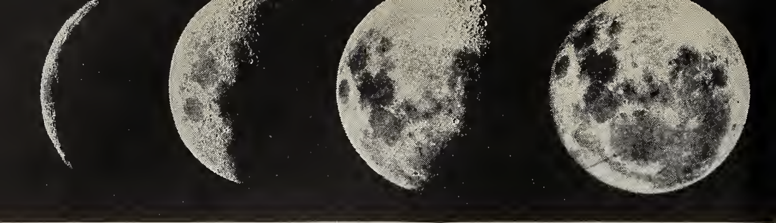
What does the word *reflect* mean?
Why is the moon not a star?
Why is moonlight really sunlight?



What is the surface of the moon like?

Did you ever see "the man in the moon"? Of course, we know that the face on the moon is really not a face at all. Do you know what it is? Let us see if we can find out.

If you went for a long hike on the moon, you would find it very rough walking in many places. There are long ranges of mountains with deep valleys, and there are great holes in the tops of some of the mountains. On some parts of the moon there are long, level plains. On this page is a picture of the moon. Do you see mountains, valleys, and plains? When light from the sun strikes the moon, these mountains make great, long shadows. We can see these shadows, and we like to imagine that they make a face.



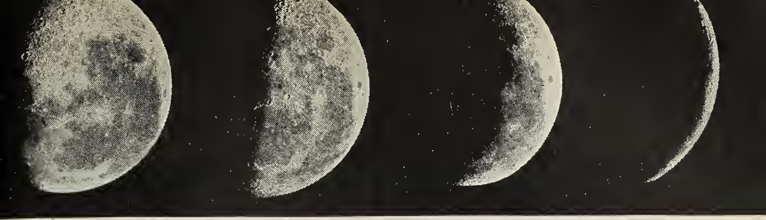
The picture shows how the moon looks from the time we first see it until it becomes full and round. The thin slice that we first see is called the *new moon.*

Scientists have studied the moon with huge telescopes and have made maps of it. They have even named many of the mountains and plains.

You would have a very, very difficult time taking a hike on the moon. Do you know why? If you remember what you studied in Unit Three, you will understand why. There is no air on the moon. So, of course, there would not be any oxygen for you to breathe. There is no water, either. With no water and no air you could never live there. There are no living things on the moon.

Why does the moon seem to change its shape?

As you have watched the moon, have you noticed that it is not always the same shape? Sometimes it looks thin and curved, like the first picture above. Then it seems to grow larger and larger, and in about two weeks it looks round. Do you know what happens then? Look at the pictures on the next page and see if you can tell what happens.



This picture shows how the moon disappears after it has been full and round. The thin slice that we last see is called the *old moon*.

Can you draw some of the moon's different shapes on the board? You have often seen the moon shaped like the pictures on these two pages. Where do you think the part of the moon is that you cannot see? It is there, but you cannot see it. You remember that the moon does not give light. We see it only because the sun shines on it.

Now let us see if we can find why we see the moon in different shapes. You remember that the sun always lights half the earth. The sun always lights half the moon, too. But from where we stand on the earth, we cannot always see all of the lighted part. This is because the moon travels around the earth. When we can see all of the lighted half, the moon looks round to us. We call it a *full moon*. Sometimes we see only half the lighted part; then we call it a *quarter moon*. At other times we can see only a very thin slice of the lighted part.

Perhaps you can understand this better if you do an experiment. Set a flash-light or a candle on

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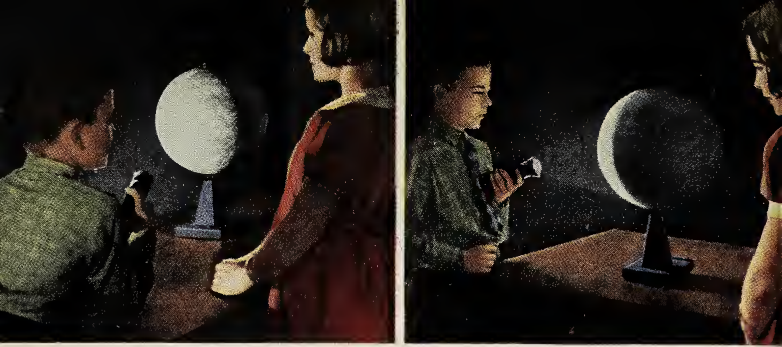


At first Mary sees most of the lighted half of the moon. But in the second picture the moon has traveled part way around her, and she sees only a little of the lighted half. What will happen as the moon travels on around her? How can you find out?

a table so that it shines on a globe. Imagine that the light is the sun, that the globe is the moon, and that you are the earth. Ask someone to move the globe slowly around you in a circle. Watch it closely as it moves. Can you always see all of the lighted part? Draw pictures of the lighted parts that you can see.

Try to find a calendar that has the different shapes of the moon on it. The first picture will show only a very small part of the moon. As the days of the month pass, we can see more and more of the moon. Finally, when almost half the month has passed, the moon will be round and full. Then, slowly the lighted part gets smaller again.

Why do you suppose the pictures of the moon are put on the calendar? It is because the way the moon moves helps us to make our calendar. The moon travels around the earth. It travels around the earth twelve times every year. This makes our months. As you know, there are twelve months in every year. The Indians used to call a month a "moon." To tell about a long journey, they might say, "We traveled for many moons."

The shapes of the moon are placed on the calendar to show you when the moon is full, when you can see only part of it, and when you cannot see it at all.

Where does the moon get its light?

Name three things you might find on the moon.

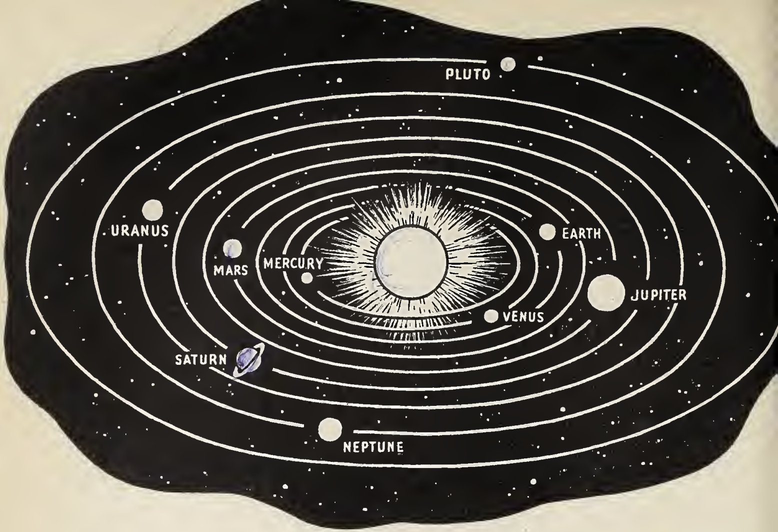
Which sentences below describe the moon, and which ones describe a star?

a) It reflects light from the sun.
b) It is a hot ball of gas.
c) It travels around the earth.
d) It is closer to the earth than any of the stars.
e) It is larger than the earth.

How many times in each month can you see a full moon?

How many times does the moon travel around the earth in one year?

Paint half of a ball white and half of it black. Hang it from the ceiling. How does the shape of the white part change as you move around the ball?



As the planets travel around the sun, each planet always stays in its own path.

What is a planet?

As you look up into the sky at night, you may see other lights in the sky that are not stars and are not moons. They are not so bright as our moon, but they get their light from the same place that the moon does. They get their light from the sun. They are *planets*. Planets look like stars, but they are quite different. All of the planets travel around the sun. None of them gives off any light of its own.

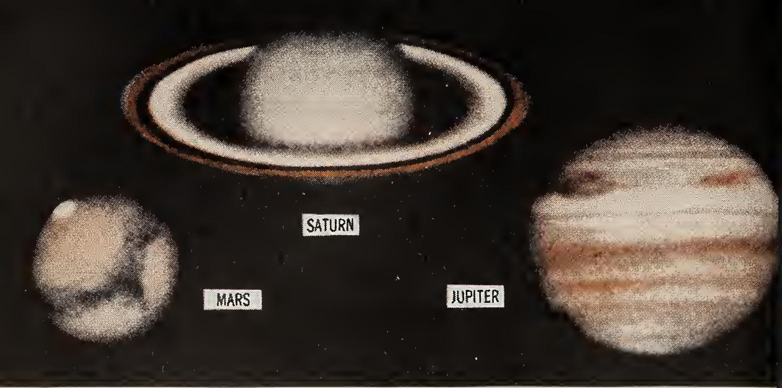
There are millions of stars, but there are only nine *known* planets. We say *known* planets because only a few years ago scientists found a new planet. Until that time the science books had said that there are eight planets. Perhaps some more planets may be found as scientists study the heavens. Almost every day scientists discover new things about the world we live in and about the heavenly bodies far out in space.

Where are the planets?

How would you like to live on a planet? Will you be surprised to know that you do live on one of the nine planets? The earth is one of the planets. You see, it does not give its own light. It is not a hot body, and it travels around the sun. Two of the planets are closer to the sun than the earth is. Study the picture on page 194 and tell which planets they are. Six of the planets are farther from the sun. Can you find the names of the six planets that are farther from the sun?

The planet nearest to the sun is called *Mercury*. You remember that it takes our planet, the earth, a year to travel around the sun. But Mercury is so close to the sun that it has a much shorter journey around the sun. Its year is only eighty-eight days long. How many days are there in the earth's year?

The planet next to Mercury is *Venus*. There are only two objects in the sky that are brighter than Venus. Do you know what they are? The



Here are three of the planets as they look when you see them through a powerful telescope. Can you find the white spot on one side of Mars? Some scientists think that this spot may be an ice cap at the pole of Mars, like the ice caps at the north and south poles of the earth.

brightest is the sun; the next brightest is the moon. Venus is the third in brightness. When you see it in the sky at night, you may think that it is the bright light of an airplane.

Venus is a beautiful planet, and you may often see it in the evening just after sundown. It is sometimes called the earth's twin because it is almost the same size as the earth. Scientists cannot find out what Venus is really like because there are so many clouds around it.

Out beyond the earth is the fourth planet from the sun. It is called *Mars*. Mars is much smaller than the earth. The earth would make six planets the size of Mars. But the year on Mars is almost twice as long as the earth's year.

For a long time people have been very much interested in Mars. They think that there might be living things on it. With their giant telescopes scientists have studied Mars and have seen great lines that look like ditches or canals. No one is sure what these lines really are, but some scientists think that they might have been made by people. Perhaps some day we shall know for sure how these markings really came to be on Mars. Scientists are making more powerful telescopes to help them study the stars, the planets, and the other objects in the sky.

Next beyond Mars comes *Jupiter*, the largest of all the planets. Jupiter is larger than all of the other planets put together. It is about a thousand times as large as the earth. Jupiter is so far away from the sun that it takes almost twelve years to travel around the sun. A year on Jupiter is twelve times as long as our year on the earth. If you lived on Jupiter, you would have only one birthday in twelve years!

Next beyond Jupiter, still farther away from the sun, we come to a planet called *Saturn*. Saturn is a most beautiful planet to see through a telescope. Study the picture of Saturn. Do you see how it is different from any of the other planets? It has rings. Sometime, when you study more about Saturn, you will find out many interesting things about these rings. Because Saturn is still farther away from the sun than Jupiter, it has even a longer year than Jupiter.

After Saturn we come to *Uranus* and *Neptune.* Then, farthest away of all, is a planet that was discovered only a few years ago. Its name is *Pluto.* Pluto is so far away from the sun that it takes 250 years to travel around the sun once. It is so far away from the sun that it is very dark and cold. Pluto cannot be seen without the help of a telescope. It is so hard to see that scientists know very little about it.

Are there living things on the planets?

You may wonder whether there are living things on any of the planets. We are sure that there are living things on one of the planets. Do you know which one that is? It is the earth.

Even the wisest scientists know very little about the other eight planets. But they have found good reasons why nothing could stay alive on most of them. Mercury is too close to the sun. It is so hot that lead pipe would melt quickly on it. So scientists are sure that it would be too hot for anything to stay alive. Some of the planets are not solid like the earth. They are made of gases. Other planets have no air on them. No one could live on these planets. Pluto and Neptune are so far away from the sun that they are colder than anything we know on earth. It is always very, very cold on these planets.

Perhaps some day scientists will find that there are living things on Mars or Venus. These planets seem to have some kind of air, so that living things might be able to stay on them. Some scientists feel quite sure that there may be some kinds of plants growing on Mars, but no one has been able to prove that this is true.

* * *

Tell two ways in which planets are different from stars.

Which planets might have living things on them? Why?

Name the planets. Begin with the one closest to the sun and end with the one farthest away.

Why do science books say, "There are nine *known* planets"?

Tell the name of the planet that:

a) Is closest to the sun.
b) Has rings.
c) Is the brightest of the planets.
d) Is called the earth's twin.
e) Is farthest from the sun.
f) Is the largest planet.
g) Seems to have canals, or ditches, on it.
h) Was discovered last.

What are "shooting stars"?

As you have watched the stars, the planets, and the moon, you may have seen still other objects in the sky. You may have been looking at the Big Dipper or Cassiopeia when suddenly a bright flash shot across the sky and disappeared. It looked like a giant sky-rocket, though it seemed to be far away. When you saw it, you probably said, "Oh! Look at the shooting star."

We call these objects "falling" or "shooting" stars, but they are really not stars. They are solid objects traveling through space out beyond the earth. When the moving earth comes near them, they are pulled toward the earth. When they reach the ocean of air around the earth, they get so hot that they start burning. Then we can see them. The real name for them is *meteor*.

These meteors are traveling toward the earth at great speed. They give off light just as any very hot thing does, and we look up into the sky and see the bright flash. As we watch this light, it disappears. Do you know what has happened? The meteor has burned up. Or perhaps it has hit the earth somewhere. The part of the meteor that falls to the earth is called a *meteorite.*

If the meteorite is a very large one, it may go deep into the earth. But most meteors break into little pieces or burn up before they strike the earth. Some meteorites are made of rock. Some are made of iron, and others are made of a mixture of iron and rock. On this page is a picture of a small meteorite that is a mixture of iron and rock.

* * *

How are "shooting stars" different from real stars?
What are meteors made of?
When a meteor disappears, what becomes of it?

Questions to Think About

1. How will scientists learn new things about the sun, moon, stars, and planets, that they do not know today?

2. Of all the heavenly bodies that you have studied, tell which

a) Is most like the earth.
b) Travels around the earth.
c) Gives the earth light.
d) Gives the moon light.
e) Warms the earth.

3. Which of these sentences say true things about the stars?

a) They are all far away.
b) They are all cold.
c) They all give off light.

4. Why is Polaris an important star to know about?

5. Some people say that if you see the new moon over your left shoulder, it will bring you bad luck. Do you believe this? Why?

6. Stories on the radio sometimes tell about people on Mars. Do you believe these stories? Why?

7. Do you think that men will ever make a rocket ship that will travel to the moon? Can you answer this question as a scientist would?

8. A boy in a science class once said, "This book that I found in the library is not a very good one to use. A newer one would be better." The book was printed in the year 1900. Do you think the boy was right? Why?

Things to Find Out

1. Look at the full moon with field-glasses and see if you can find plains and mountains.

2. Read some stories about constellations that are not given in this book.

3. Make a chart of the constellations you can find as you face north.

4. Make a chart of the constellations you find as you face south.

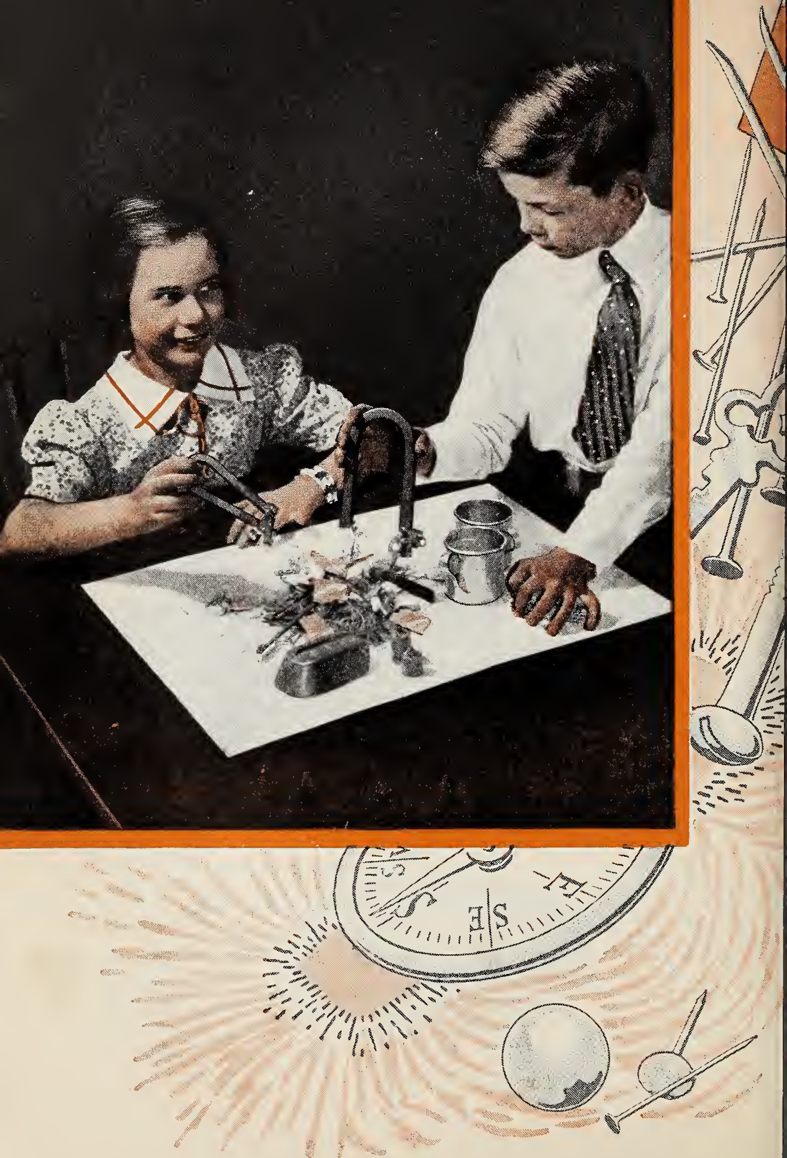
5. Keep a record on your calendar of the different shapes of the moon as you watch it for a month.

6. Learn to find Venus, Saturn, and Jupiter during the months when they can be seen.

7. Look at the sun through smoked glass.

8. Try to find different colored stars.

9. Show the constellations you know in different ways, such as,
   - *a*) Use Christmas tree lights for the stars on a large blue cardboard.
   - *b*) Cut holes in blue paper to show the positions of the stars in each constellation. Slip the paper into the open end of a box. Then hold an electric light or flash-light inside the box.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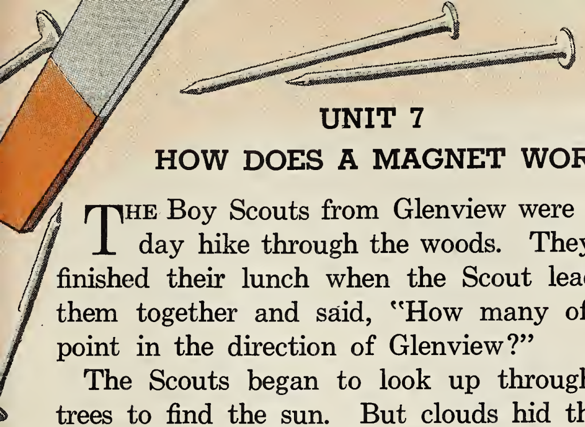


UNIT 7

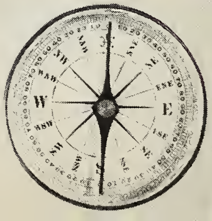
HOW DOES A MAGNET WORK?

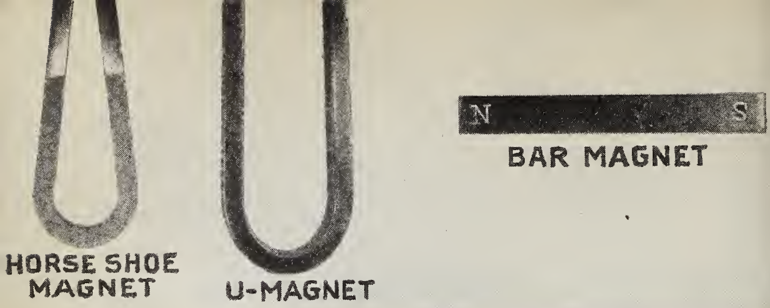
THE Boy Scouts from Glenview were on an all-day hike through the woods. They had just finished their lunch when the Scout leader called them together and said, "How many of you can point in the direction of Glenview?"

The Scouts began to look up through the tall trees to find the sun. But clouds hid the sun; so the sun could not help the boys find their directions. One by one the boys began to point in the direction they thought was home.

When the last boy had pointed, the Scout leader laughed and said, "There are only three boys who have pointed in the right direction. Most of you need something to show you how to get home. There are really two things you need. One of them I will give you." He handed Billy a small round object. "The other one I will tell you. Glenview is east of here. Now, Billy, suppose you point in the direction of home."

Do you know what the Scout leader gave Billy? It was a compass like the one in the picture below. Do you see the long, pointed needle? One end of that needle in a compass always points toward the north. The needle is made of steel, and it is called a *magnet*.





In the next few pages you will learn some important and interesting things about magnets. As you study magnets, you will understand how the compass could help Billy and the other Scouts find their way home. You will discover other interesting things about magnets. You will learn that:

A magnet has no fingers, yet it can pick up things. Sometimes it can pick them up better than you can with both your hands.

A magnet has no brain, yet it will pick up only certain things. And it never makes a mistake in the things it picks up.

A magnet has no tongue, yet it can tell you which direction is north and which is south.

What kinds of magnets are there?

Magnets are not all shaped like the magnet in the compass. Above is a picture of some of the kinds of magnets. Find the one that is shaped like a horseshoe. What are the names of the others?

Most magnets are made of steel. Steel is a

This small magnet will lift a large pair of scissors.

metal that is almost all iron. A few years ago science books said that *all* magnets are made of iron or steel. But even while this book was being written, scientists discovered a new way of making a magnet. This new magnet has in it three other metals besides iron. These metals are aluminum, nickel, and cobalt. The new magnet is very strong. It will pick up a piece of iron or steel many times as large as itself.

There is another kind of magnet. It is found in the ground, and you would never guess that it is a magnet. It looks like a rusty piece of rock, and it is called *lodestone.* Lodestone has much iron in it, and somehow it has become a magnet. It was the first kind of magnet that men knew about.

We do not know who first discovered lodestone. Many different stories are told about how it was found. One of these tells of a shepherd named Magnes. His long shepherd's staff had an iron tip on the end of it. While he was watching his sheep one day, he laid his staff against a rock. When he tried to pick it up, the iron tip stuck to the rock. He had to pull to get it away from the rock. He was so puzzled that of course he told all his friends about it. Perhaps the magnet was named after the shepherd Magnes.

What kinds of things will magnets pick up?

You can learn many things about magnets by experimenting with them. There are some experiments in this book, and you may be able to think of other experiments to do. Be sure to use the magnets carefully. Then your experiments will tell you true things about magnets. If you are not careful when you experiment, you may make mistakes.

Turn back to page 206 and read the first two things a magnet can do. Can you plan an experiment to show that a magnet can do these things? Find as many of these as you can: tacks, needles, nails, pins, paper clips, bits of cardboard, iron, and wood, some sand, something made of glass, a piece of chalk, scraps of paper, and a tin cup. Also have some iron filings. These are small bits of iron that have been shaved off by a file.

Now get a magnet and see how many of the things it will pick up. Make a list of everything the magnet picked up. Did it pick up the nails, tacks, paper clips, pen-points, iron filings, and needles? What are these things made of? Did the magnet pick up anything made of glass? Of cardboard? Of paper? Of rubber? Of wood?

Look carefully at the things that the magnet picked up. Do you know how they are all alike? They all have iron or steel in them. Did you notice that the magnet pulled each of these things to it? When you wanted to remove one of them, you had to pull harder than the magnet was pulling. We say, "A magnet *attracts* iron and steel." That means that a magnet pulls iron and steel toward it. This pull that the magnet has is called a *force*.

* * *

Why is it important to do experiments carefully?

Which of these things will a magnet attract: a pencil, a penny, a rubber band, a pebble, an iron nail? How can you prove that your answer is right?

Will a magnet's force pass through things?

You have learned that magnets attract only iron and steel. But what did your magnet do with the tin cup? It picked up the tin cup just as it did the iron nails and pins. Do you think, then, that magnets attract tin?

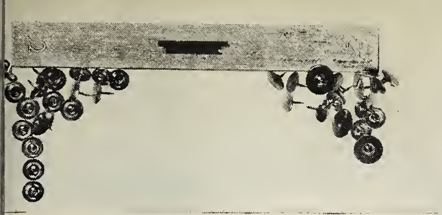
Here is an experiment that will help you to understand why the magnet picked up the tin cup. Lay a piece of glass on some books, as you see in the picture on the next page. Put some nails on the glass. Hold a magnet against the glass under the nails. Move the magnet around. What happens to the nails? Does the force of the magnet pass through the glass?

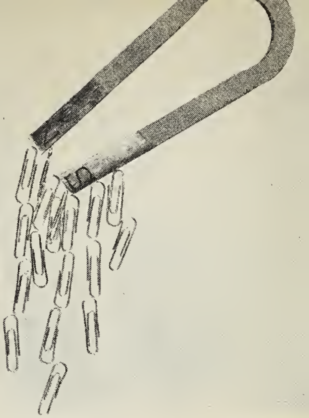
The cups that we call tin are almost all iron. Most of the things that we call "tin" have only a thin coating of tin over them. Magnets will not pick up tin, but the force of the magnet goes through the tin and attracts the iron in the cup. Can you think of an experiment to show that a magnet's force passes through thin wood, paint, cloth, and paper?

You cannot see this strange force of a magnet, but you can see what the force does. You have learned two things about it. It will pull iron and steel, and it will pass through many kinds of things.

What are the poles of a magnet?

There is another important thing to learn about a magnet's force. Get some iron or steel thumbtacks. How can you tell that they are made of

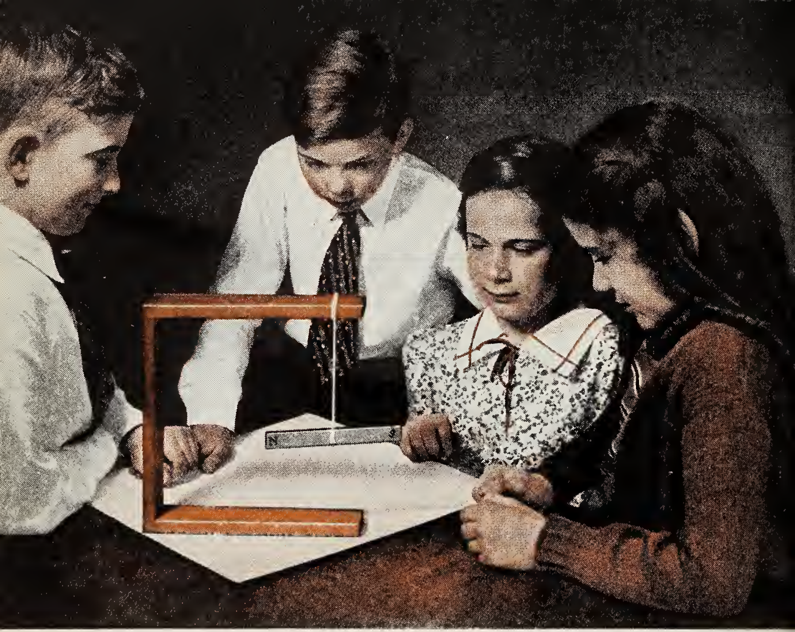




steel or iron? Hold a bar magnet in one hand and try to hang the thumb-tacks to the magnet. Begin at one end and work toward the center. Which part of the magnet holds the most tacks? Try both ends of the magnet. Where is the force of the magnet strongest?

Now do the experiment in a different way. This time spread iron filings on the bottom of a box. Then lay a bar magnet on the filings and roll it over them. Pick up the magnet. Where do most of the filings stick to the magnet? Try this experiment with a horseshoe magnet and with a U magnet.

If you have experimented carefully, you have discovered that the pull of the magnet is strongest at the ends. These ends of a magnet are called its *poles*. One end is called the north pole, and the other is called the south pole. As you know, magnets have different shapes, but all magnets have a north pole and a south pole. The end marked N is the north pole, or N pole, and the end marked S is the south pole, or S pole. On some magnets the poles are not marked.



Now let us see if we can find why the ends, or poles, of a magnet are called north and south. Twist a piece of wire tightly around the middle of a bar magnet and tie some string to it. Hang the magnet from a wooden frame as shown in the picture.

When you hang the magnet up, be sure that it can swing around easily and be sure that there are no other magnets near. Your magnet will swing for a while and then stop. When it has stopped swinging, in what direction does the N pole point? Do you see why it is marked N? Try the experiment again. Try it with other magnets, too. Then you will be sure that all magnets act in this way. Because this pole points north, we call it the north pole. It really is the north-pointing pole. The south pole of the magnet points toward the south, and so it is marked S.

* * *

Draw pictures of three shapes of magnets and put an X in the places where the pull is strongest.

What is the pole of a magnet?

How is the magnet that you hung from the frame like the magnet in the Scouts' compass?

What is the field of force of a magnet?

You have probably learned that you do not need to touch a piece of iron to make a magnet attract the iron. When you bring a magnet near a small piece of iron, the iron jumps to the magnet. The force of the magnet makes the iron move to it.

Perhaps you can think of an experiment that will show how far a magnet can attract a piece of iron. The picture shows one way to find out. The boy is slowly moving the magnet

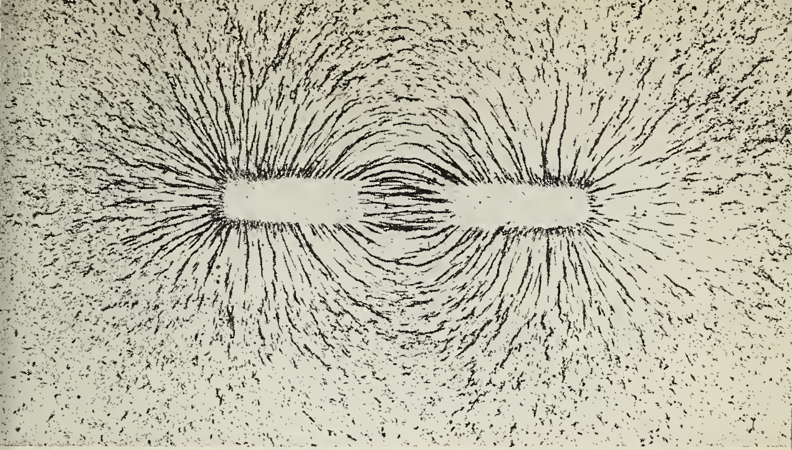
nearer the nail. Does the nail roll to the magnet? Try it and see. Try different kinds of magnets and find out which of your magnets has the most force.

Now let us learn something more about the force of a magnet. Hold the magnet above a tack, then at one side of the tack, then at the other side. Does it pull the tack, no matter what side it is on? You might even swing a tack on a thread above a magnet to see whether the pull will stop the swinging of the tack.

Do you see that the force is all around the magnet? It goes up from the magnet, and down, and sideways. We say that a magnet has a *field of force.* Wherever the magnet pulls is called the field of force, or the *magnetic field.* When a bit of iron is in this field of force, the iron is pulled by the magnet.

You cannot see this field of force, but you can make a kind of picture of it. If you are careful, your picture will look like the one on the next page.

First, lay a bar magnet flat on a table. Then cover the magnet with a piece of thin cardboard. Sprinkle iron filings on the cardboard. If you put the iron filings in a salt shaker, you can sprinkle them more evenly over the cardboard. Tap the cardboard lightly. Do you see how the iron filings draw together in lines? These lines help to give us a picture of the field of force.



Look farther from the magnet and you will see that the force of the magnet seems to stop. The iron filings look just as they did when you sprinkled them on the paper. The force of the magnet has not moved them. The force becomes weaker and weaker the farther we get from the magnet. Finally the force is so weak that it will not move the filings at all.

The picture on this page shows the magnetic field around a bar magnet. Can you see the lines of iron filings? Can you tell where the field of force gets weaker?

* * *

Could you use copper filings to show lines of force in a magnetic field?

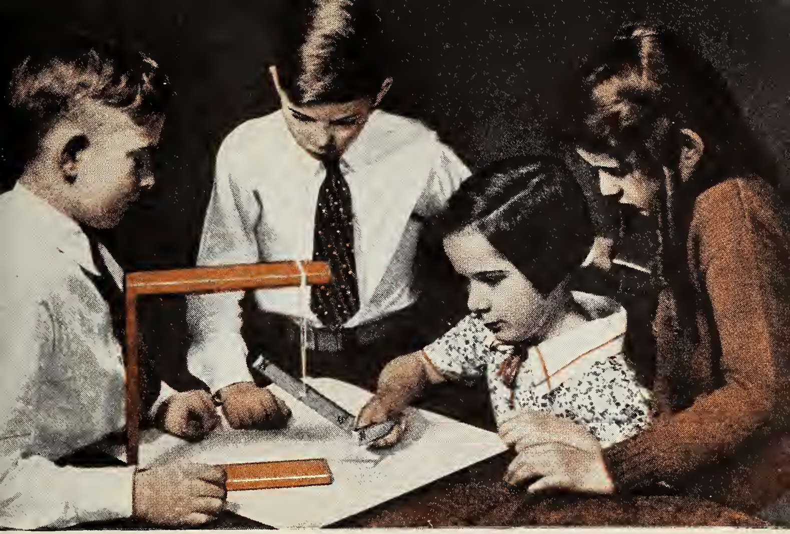
Where is the field of force of a magnet?

What does this picture tell you about the way in which magnets act when they are held near each other?

How do magnets act toward each other?

Do you know what happens if you bring one magnet near another magnet? Here is a way to find out. Hang a bar magnet in a frame as you did before. Hold another bar magnet in your hand and bring the end marked N near the N pole of the hanging magnet. What happens? Now bring the S pole of the magnet in your hand near the S pole of the hanging magnet. What happens this time?

You have found that when two north poles of magnets are brought near each other, they push each other away. Or you might say that one N pole pushes another N pole away.



This picture shows you something else about how magnets act toward each other. Before you read the next page, see if you can tell what it shows.

You have also found that when two south poles are brought near each other, they push each other away. One S pole pushes another S pole away. This shows that when two poles of the same kind come close to each other, they push each other away.

Two poles of the same kind are called *like* poles. Like poles of magnets push each other away. If a scientist were telling this, he would say, "*Like* poles of magnets *repel* each other." *Repel* means to push away.

Now suppose you hold the north pole of a magnet close to the south pole of the hanging magnet.

What happens? Hold the south pole of the magnet near the north pole of the hanging magnet. What happens? These poles are not alike. One is a north pole, and one is a south pole. We call these *unlike* poles. A scientist says, "*Unlike* poles of magnets *attract* each other."

You have found out by your experiments that:

Like poles of magnets *repel* each other.

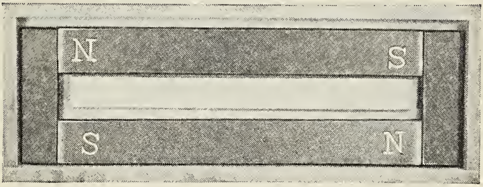
Unlike poles of magnets *attract* each other.

We call these facts the *laws* of magnets. A law in science tells how something *always* acts. You need never wonder how a magnet is going to act. The laws of magnets will tell you.

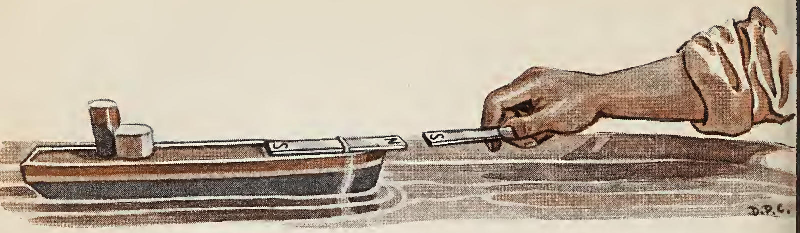
Perhaps you can think of other ways to show the laws of magnets. Try to pick up one bar magnet with another. Can you pick up one magnet with another if you put the like poles together? Try the unlike poles. Use two horseshoe magnets and show the laws of magnets by trying to pick one up with the other.

Suppose you have a magnet on which the poles are not marked. Can you use the laws of magnets to find out which end of it is the north pole? Use an unmarked U-shaped magnet. Touch one end of the U-shaped magnet with the S pole of a bar magnet. If the two poles of the magnets pull each other, what does this tell you about the pole of the U magnet? If they do not pull each other, which pole of the U-shaped magnet do you think you are touching? Touch the other pole of the U-shaped magnet. Do the magnets pull each other now?

If you remember the laws of magnets, you will know that unlike poles attract each other. So when you find which pole of the U magnet pulls the S pole of the bar magnet, you have found the north pole. Place a large N on the pole of the magnet with a piece of chalk. Now mark the other end S. Could you use this magnet now to mark the poles of another magnet?



In taking care of magnets you should be careful not to leave them lying with like poles together. They will lose their strength if they are left in this position. A piece of iron, called a *keeper*, should be placed over the poles of a horseshoe magnet and of a U magnet. Bar magnets should be placed north and south, with the N pole of one placed next to the S pole of the other. Strips of wood may be placed between magnets if they are laid close together.



If you know the laws of magnets, you can easily make a magnetic boat that will sail away from you or toward you. First, make or get a wooden boat large enough to carry a bar magnet. Place the magnet in the boat with the N pole at the front, or bow, of the boat, and put the boat in a tub of water. Now hold the N pole of another magnet near the bow of the boat. Does the boat move away from you? Hold the S pole of the magnet near the bow of the boat. Which way does the boat move?

You can move the boat in any direction if you remember that like poles of magnets repel each other and unlike poles attract each other.

Write the laws of magnets on the board and prove, by using two magnets, that you have written the laws correctly.

What is a law in science?

How should you take care of magnets so that they will not lose their strength?

Why do magnets point north and south?

Do you remember how Billy and the other Scouts learned to use a compass to find their way home? A magnet in the compass pointed north and south. Since you read that story, you have learned several things about magnets. You have seen that the N pole of a hanging bar magnet points north.

But there is one more thing you need to know before you can explain why a compass magnet and a bar magnet point north and south. First, let us make a list of four of the important things you have learned about magnets.

You know that:

1. Every magnet has an N pole and an S pole.
2. The S pole of one magnet will push the S pole of another magnet away. Also, two N poles will push each other away.
3. The N pole of one magnet will attract the S pole of another magnet.
4. The field of force reaches for some distance around the poles of a magnet.

Can you use these facts to figure out why a compass magnet and a swinging bar magnet point north and south? Would you guess that there must be a great big magnet somewhere that pulls on all little magnets? If you made that guess, you would be correct.

The earth itself is a huge magnet. Perhaps that is hard for you to believe, but it is true. You have learned three shapes of magnets: the bar, the U, and the horseshoe. Each of these has a north pole and a south pole. A magnet may also be in the shape of a ball. It, too, will have a north pole and a south pole. One pole will be on the opposite side of the ball from the other pole.

The earth is a great magnet in the shape of a ball. Like all magnets, it has a magnetic north pole and a magnetic south pole. The magnetic north pole is found in the far north, and the magnetic south pole is found in the far south. All around the earth is a great field of magnetic force. It is just like the field of force around any other magnet.

Do you remember how the poles of the bar magnet pulled the iron filings that were in the field of force? Then think how far the force of the big earth-magnet must reach! The pull of the two magnetic poles reaches out a long, long distance from the poles.

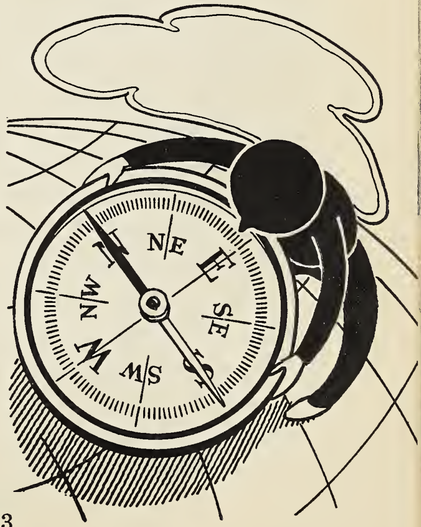
No matter where you are on the earth, the magnetic north pole will pull one end of a compass needle toward it. And the magnetic south pole will pull the other end. That is why the boys' compass needle pointed to the north and south. The pull of the magnetic pole drew it that way.

How do we read a compass?

Suppose you examine a compass carefully. Notice how easily the small magnet moves. Then look at the card beneath the needle. Do you see the printed letters that stand for the directions? N is for north, E is for east, S for south, and W for west. Notice that half-way between north and east is a point marked NE. This half-way point is called northeast. Find the point that marks southeast. Find the points for southwest and northwest.

On some compasses the words "blue end points north" are printed. This means that the north pole of the compass needle has been colored blue to help people read directions.

If you have a compass with a needle that is colored on one end, this is the way to use it. Hold the compass in the palm of your hand so that it will be level. When the needle stops swinging back and forth, the blue end of the needle will point north.



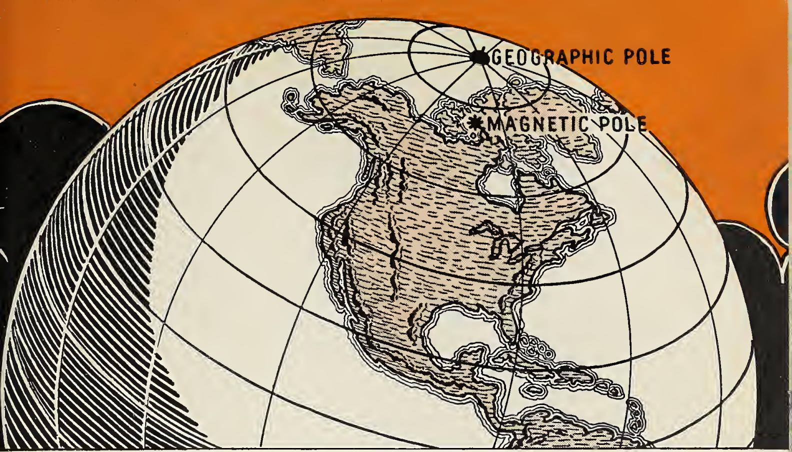
Now turn the case of the compass around so that the letter N is just under the blue end of the needle. The needle shows you which direction is north; so you can easily find the other directions. Which way will south be? When you face north, east will be toward your right and west toward your left.

Use your compass to do these things:

1. Walk twenty steps east.
2. Point to the south wall in your school-room.
3. Face northwest.
4. Face southwest.
5. Tell in which direction your school faces.
6. Tell the direction of your house from the school building.

Now you can understand how the boys used their compass. The blue needle pointed north. Then they could find the other directions and tell where Glenview was.

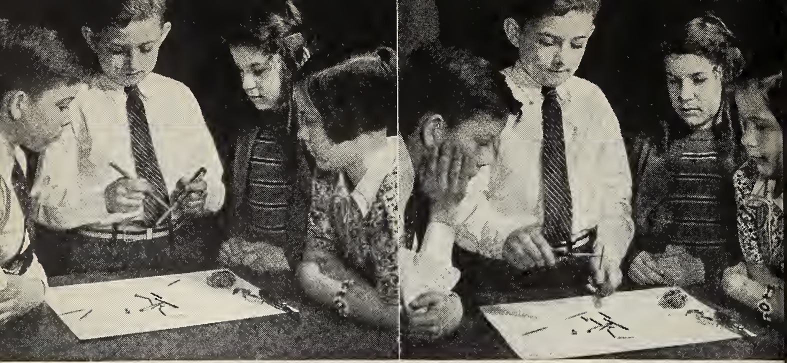
No one knows who first made a compass, but in a book written hundreds of years ago there is this story. On cloudy nights when sailors could not see the North Star, they rubbed a steel needle on a piece of lodestone. This made a magnet of the needle. Then they put the needle on a small piece of wood and floated it in a pan of water. The needle turned the wood until it pointed north and south. Lodestone is sometimes called *leading stone* because it was once used to help find directions.



Perhaps you have been wondering if the compass needle points toward the North Pole that is at the end of the earth's axis. We call this pole the *geographic* North Pole. The compass does not point toward this North Pole. It points toward the *magnetic* north pole.

Study the map that shows you where the magnetic north pole is and where the geographic North Pole is. You can see that the two poles are not at the same spot on the earth. The geographic South Pole and the magnetic south pole are also far apart. The compass, of course, points toward the magnetic north and south poles.

You can see that when the compass needle points toward the magnetic north pole, it may not be pointing exactly north. But it points so close to north that we can use it to find directions.



What is Bobby doing to his knife to magnetize it? Look at the second picture and tell how he is proving that his knife is now a magnet.

How can you make a compass?

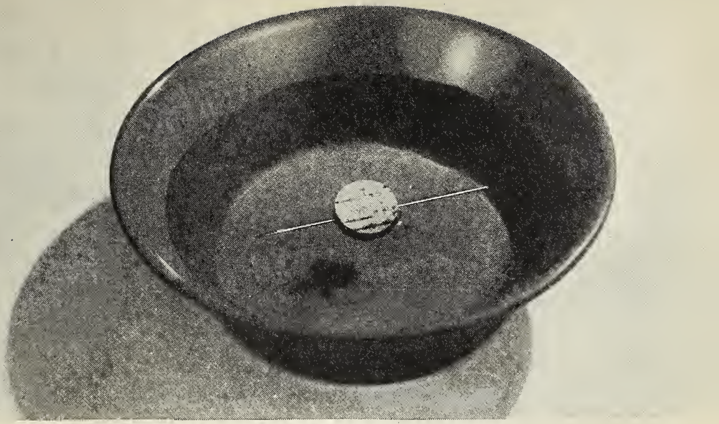
A compass is not very hard to make. All you need is a magnet, a needle, a flat piece of cork, and a dish of water. Before you read the directions, first try to figure out how to make a compass with these things.

Here are the directions:

Make a magnet of the needle by rubbing it on one end of a bar magnet. We call this *magnetizing* the needle. Be sure that you rub the needle only one way on the magnet. Do not rub it back and forth.

Make a tiny groove in the top of the flat piece of cork and lay the needle in the groove, or push the needle through the cork.

Float the cork and the needle in the water. Place them on the water carefully so that the cork will



This floating compass is made by pushing the magnetized needle through the cork. Probably the first compasses that men ever made looked something like this one.

not touch the side of the dish. It must be near the center so that it is free to swing around. If your compass has been made carefully, the needle will point north and south. The magnetic poles of the earth attract the floating needle just as they do the needle in a compass and just as they do a bar magnet that is hung in a frame.

Some boys and girls were once making a compass like this, and when they floated the needle on the cork, it did not point north. What do you think was wrong? They tried to magnetize the needle more carefully. Still the compass needle would not point north.

Peggy thinks there is something wrong with her compass. Do you know what is wrong?

Finally, after they had almost given up trying to make the compass work, one of the boys discovered what was wrong. He pulled out the drawer of the table and found three horseshoe magnets. As soon as these magnets were carried farther away from the compass, the needle swung around and pointed north and south!

Some people think that the compass is one of the most important inventions ever made. Do you think this is true? Men who sail ships must use compasses to show them the way across the ocean. There are no sign-posts to help the ship find its way. The captain watches the compass to find out if the ship is traveling in the right direction. Even if the ship is going through a heavy fog in the darkest night, the compass still shows the way. Think how many safe journeys on sea have been made with the help of a compass!

Explorers have used compasses to help them find new lands. It was the compass, you know, that showed Christopher Columbus his way across the Atlantic Ocean to the new world of America. During both day and night it told him which direction was west. Hunters and trappers carry compasses to help them as they tramp in the thick woods. So do explorers who go on long travels through strange lands.

* * *

Why must a compass needle turn easily?

Is this correct? To magnetize a needle, rub it back and forth on a magnet.

Questions to Think About

1. Could you make a compass without a magnet? Why?

2. Where would the magnetic poles have to be to make compasses point exactly north and south everywhere on earth?

3. How could a magnetic tack hammer help you to keep from hitting your fingers when you were driving tacks?

4. A story was once told of a thief who stole money from people's pockets with a magnet. Do you believe the story? Why do you think it was true or was not true?

5. Make five sentences beginning with these two words: "All magnets ...." Be sure the sentences say true things. One of your sentences might be: All magnets can pick up iron.

6. Make five sentences that begin with "Some magnets ...."

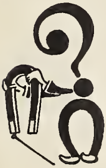
7. Bud and William were doing a science experiment. They were trying to find out if a magnet would pick up pins. Bud tried four pins that were lying on the science table. The magnet picked them up. Bud said, "Magnets will always pick up pins."

William found some other pins and tried to pick them up with a magnet. He discovered that the magnet would not pick up some of the pins he had found. William said, "Magnets will not pick up all pins. They will pick up only those that are made of iron or steel."

Which of the boys was the better scientist? Why do you think so?

If the two boys were telling you things they knew about magnets, which boy would you rather believe?

Things to Find Out



1. Find out if these things are true by doing some experiments with magnets.
    - *a*) Some magnets are stronger than others.
    - *b*) Magnetic force will travel through a piece of leather.
    - *c*) A nail is a magnet itself when it is touching a magnet.
    - *d*) A knife blade may be magnetized by rubbing it with a magnet.
    - *e*) A magnet may be used to pick iron filings out of sand.

2. Find out whether the force of a magnet will pass through iron and steel.

3. See if you can use a compass to find out which of two magnets is the stronger.

4. Make a magnetic theater. Make a toy stage out of a cardboard box by painting it and fastening curtains to the open side. Make figures of the players out of cardboard. Fasten paper clips or tacks to their feet. You can move the players by moving a magnet under the cardboard stage.

UNIT 8

WHAT MAKES THINGS MOVE?

BILLY AND Betty Bates and their father and mother were on a vacation trip in their car. One afternoon as they were riding along a country road, the engine of the automobile suddenly began to cough and sputter. The car began to slow down; then it stopped.

"We are out of gas," said Mr. Bates as he tried to start the car again. "Too bad we couldn't have gone about a hundred yards farther. There is a filling station down the road at the bottom of the hill."

"Let's see if we can push the car to the top of the hill," said Bill. "I think the four of us can do it. Then maybe the car will roll down as far as the filling station."

The Bates family climbed out and got behind the car. They pushed as hard as they could. But it was uphill, and the road was sandy. The big car hardly moved. Soon they were tired out and had to give up.

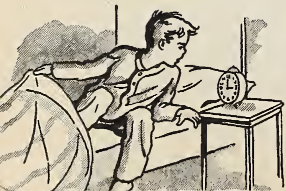
"Come on, Bill," said Mr. Bates. "We'll have to walk down to the gas station and bring back some gasoline. We will use the force of our muscles to get gasoline for our car. Then we will use the force of the gasoline to move us along the road again."

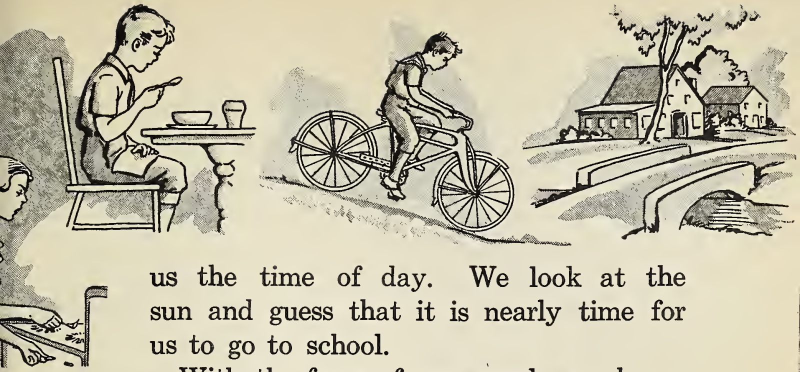
What is a force?

Do you know what Mr. Bates meant when he talked about *force?* He was talking about something that could move the car. Unless something made the car move, it would always stay in the same place. Nothing moves unless something pulls it or pushes it. You have seen that magnets have a force and can move iron and steel. Everything that moves is either pulled or pushed by a force.

Let us imagine that we wake up some morning and find that there are no forces left in the world. But wait. We shall have to keep one force, or we cannot even get out of bed to look around. We shall need to keep the force of our muscles.

We climb out of bed and look at the clock. It has stopped. The clock is run by electricity or by a spring that we wind up. But there is no electrical force any more, and there is no force in the spring. Of course the hands of the clock do not move to tell





us the time of day. We look at the sun and guess that it is nearly time for us to go to school.

With the force of our muscles we hurry to the bathroom to wash. We turn on the water faucet, but no water comes. There is no force; so of course the water cannot move in the pipes. Mother tries to light the gas stove to cook breakfast, but there is no gas. The gas cannot move through the pipes, because there is no force to move it.

We eat a cold breakfast and start to school on a bicycle. We come to a hill that we always used to coast down. But something strange happens! Instead of coasting down the hill, we have to keep on pedaling and using the muscle force of our legs. The force that used to pull us down the hill is gone.

We come to a little stream that used to flow swiftly under the bridge. The water is as still as it can be. There is no force to move it! There is, of course, no wind this morning, for there is no force to push the air around.

Automobiles, street-cars, and buses are standing right where they were when the forces stopped moving them. A long freight train stands still on the tracks. Its engine is silent. There is no force of steam to move it.

There are no electric lights and no electric signs, because the forces that move the machinery to make the electricity have all stopped. What a strange world this seems to be with not a moving thing in it!

But there is something wrong with our story. We really used another force besides our muscles. It was a force that kept us and everything else from flying off this spinning earth on which we live. Do you know what that force is? The following pages will tell you about this force.

What is the greatest force in the world?

The greatest force in the world is one that pulls on everything you see around you. It is pulling on you now as you read this page. It pulls on the book you are reading, and it pulls on your pencil and tablet. It pulls on everything, and it keeps on pulling all the time.

You easily see how this force works if you drop your pencil. The force pulls the pencil to the floor. Do you know the name of this force? It is called the force of *gravity*. We have always used the force of gravity, but there are still many things that we do not know about it.

What force will start the sled moving? What force will keep it moving downhill?

Scientists have been studying the force of gravity for a long time. Many, many years ago a scientist named Isaac Newton was walking in an apple orchard. As he walked along, he saw an apple fall from a tree. Newton said to himself, "I wonder why the apple falls to the ground. Why doesn't it fall *up* instead of *down?*" Then he began to think of all the other things that fall.

Of course, everyone knew that everything that is dropped falls toward the earth. Unless things are held back in some way, they will always fall from high places toward low places. Rocks roll down hillsides, and water flows downhill. Someone once said, "Everything that goes up must come down." But no one had stopped to wonder why things fall.

Newton was one of the first men to study how this force of gravity works. He found out many things about gravity because he thought about it and

In each of these pictures something is falling because the force of gravity is pulling it down.

wondered why it pulled on things. Did you ever wonder why things do not fly off the swiftly spinning earth? Gravity is the pull that holds things to the spinning, whirling earth. Everything would fly off the earth if gravity did not hold things down.

Do you know how much gravity pulls on you? There is an easy way to find out. All you need to do is weigh yourself! It is the pull of gravity that gives you your weight. The scales on which you weigh yourself measure the force, or pull, of gravity on your body.

It is the force of gravity that pulls you and your sled downhill in winter. After you have pulled your sled up the long hill, you face it toward the bottom and then sit down on it. Someone may give you a little push, and away you go! Gravity is pulling you faster and faster until you reach the bottom of the hill. It pulled you from a high place to a low place.

If the Bates family could have pushed their car to the top of the hill, gravity would have pulled the car down the long hill to the gas station.

How many things in your school-room can you name that are pulled by the force of gravity? Remember that anything that has weight is pulled by gravity.

* * *

How many of the following things are pulled by the force of gravity? A feather, a rock, a noise, a pail of water, sunshine.

Why does the water sink into the ground after a rain?

When you weigh yourself, what are you finding out?

Which of these sentences is not correct?

1. Gravity makes rivers flow.
2. Gravity does not pull on a book if the book is lying on a table.
3. Rain falls because gravity pulls on it.

Before the white man came, the Indians had never learned how to use the important forces that we use today.

How does the force of muscles help us?

You have already learned that your body is moved by your muscles. Your muscles can pull and push so that you can walk, run, play, write, lift a book, and move your body in many ways. The force of your muscles was the first force you learned to use to move things.

Muscle force was the first force that men ever used to pull and push things. They used muscle force to build their homes and to do their work in the fields. Everything they moved was moved by the force of their own muscles.

After a time men began to use the muscle force of animals to help them. Animals were trained to pull wagons, carts, and plows, and to carry loads on their backs. Horses and oxen pulled plows over the fields and pulled wagons along the roads. Even dogs were used to carry and to pull loads. Horses, oxen, and dogs still pull loads for men. Have you ever used the muscle force of animals?

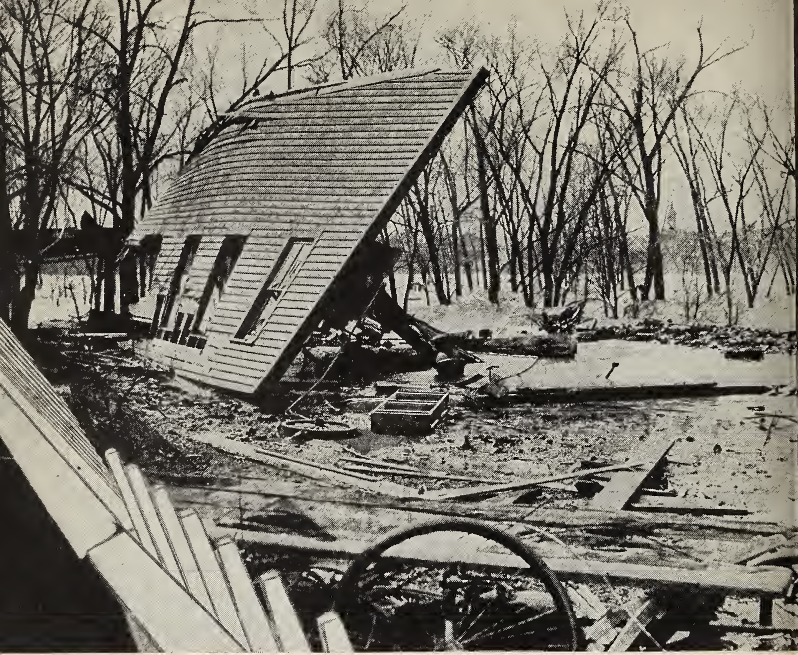
Do you know where muscles get the force to pull and push and lift? If you remember what you learned about the human machine, perhaps you can tell. And if you should go without food for three or four days, you would know where the muscles get their force. Perhaps you have read stories of people who were lost for days without food. You know that they became so weak that they could not walk or even call for help.

The force that your muscles have comes from the food you eat. A glass of milk, an apple, and a piece of meat cannot do any moving by themselves. But your body can change them so that they give force to your muscles. Then your muscles can move your body, and you can throw things, lift things, and in other ways make things move. Every living thing must have food, or it cannot move itself or any part of itself.

* * *

How have you used the force of your muscles today?

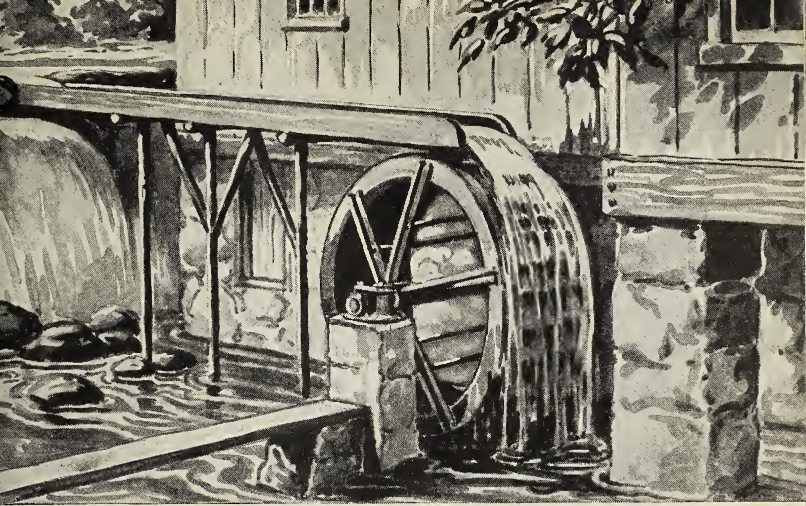
Where does the force of your muscles come from?



How does water make things move?

If you have ever stood in a swift stream of water, you have felt the force of the water as it raced past you. If the water moved very fast, it may have had enough force to push your feet out from under you. Moving water is another force that men learned to use long, long ago.

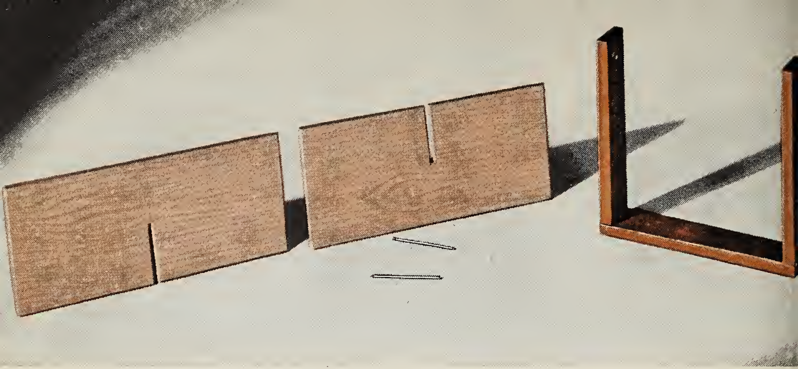
Terrible floods show us, perhaps best of all, what great force there is in moving water. On this page is a picture of a building that has been wrecked by a great flood of water. Do you see what has



happened to the building? It has been lifted up, tipped over, and smashed by the force of the water. Mud and parts of other buildings have been carried here by the water.

But the force of moving water does not always do harm. On this page is a picture that shows how men have learned to use the force of water. Can you see what makes the water-wheel go?

It is turned by the force of the moving water of the stream. The water falls on the paddles of the wheel and pushes the wheel around. When the wheel turns, it moves the machinery in the mill. The machinery grinds corn and wheat into flour. The miller is using the force of running water to do his work.



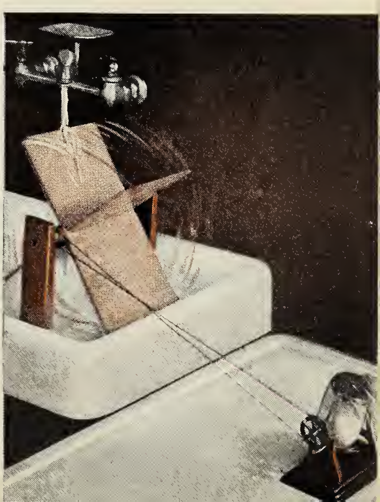
You can make a water-wheel from these parts.

Some kinds of water-wheels are used to turn machines that make electricity. The water strikes the paddles of the wheel, and the wheel turns the machines. Perhaps the electricity that lights your school-room and runs the street-cars in your town is made when water moves a water-wheel.

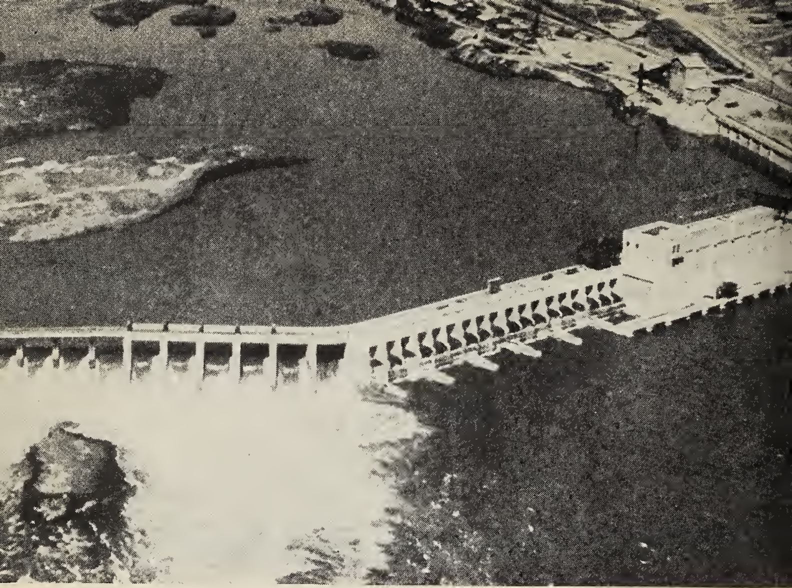
You can easily understand how the force of water can make things move if you make a water-wheel and watch it run. Study the pictures on this page. They show a kind of water-wheel that you can make. Find a thin board and cut it into pieces to make the paddles. Then fasten the paddles together as they are in the picture. When the wheel is finished, hold it under a faucet and let the water fall on the paddles. Does the wheel turn? Open the faucet so that the water will run faster. Does the wheel turn faster? When the water runs fast, it has greater force. When the force is greater, the wheel moves faster.

If you have made your water-wheel carefully, you may be able to use it to turn another wheel. Fasten a spool to the water-wheel as it is in the picture on this page. Look carefully at the picture. Do you see how the spool is connected with the small wheel on the toy churn by a strong piece of string? Now you can see how the force of running water may be used to make machines go.

Before men learned how to make gasoline engines and steam-engines, they built their factories near streams that flowed swiftly. Then they could use the swiftly flowing water to run the machines in the factories.



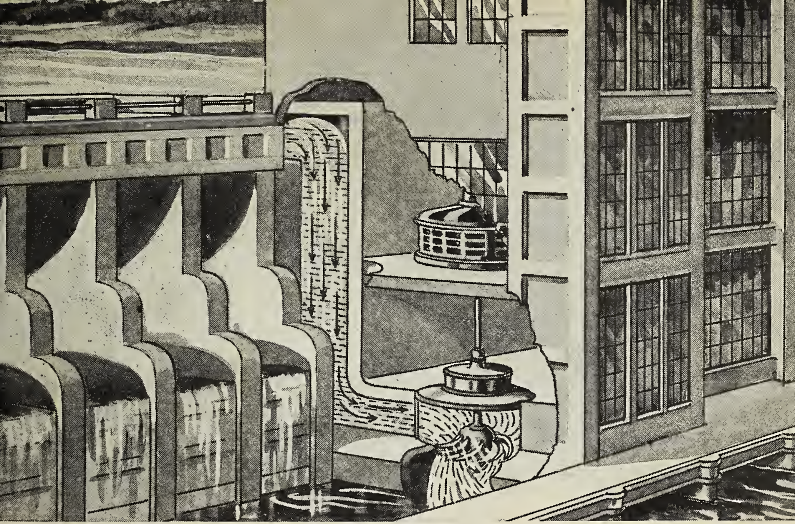
The water that turns a water-wheel would never move unless something pulled it or pushed it. It is pulled by the same force that pulls your sled downhill over the snow. This force, you remember, is



Dams like this one are called *power dams.* In the building at the right are the machines that make electricity. They are run by the force of the water falling over the dam.

gravity. Gravity makes water run from high places to lower places everywhere on the earth.

Men often raise the water in a river or stream so that when it falls it will have greater force. To do this they build a dam across a river. The water keeps flowing down against the dam. It keeps rising higher and higher behind the dam as the dam holds it back. Finally, the water rushes over and falls swiftly from the top of the dam to the bottom. At the bottom of the dam are many



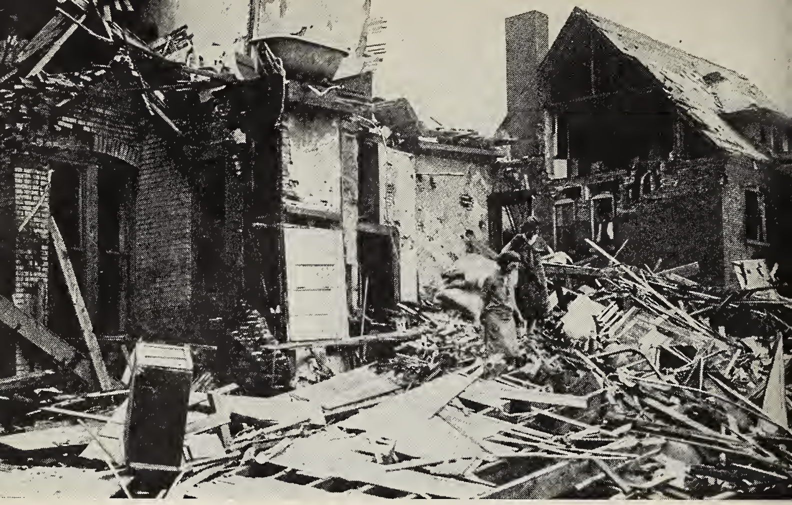
This picture will help you to understand the picture on page 246. It shows one end of the dam and a part of the building where the machinery is. Do you see how the water falls from the top of the dam through a big pipe to a water-wheel? The water-wheel is connected to a machine above it.

water-wheels. The water falls on the water-wheels with great force and makes the wheels turn fast.

Which water-wheel will have more power, one that is in a stream flowing down a mountainside, or one that is in a stream on almost flat land? Why?

Why are factories often built near rivers?

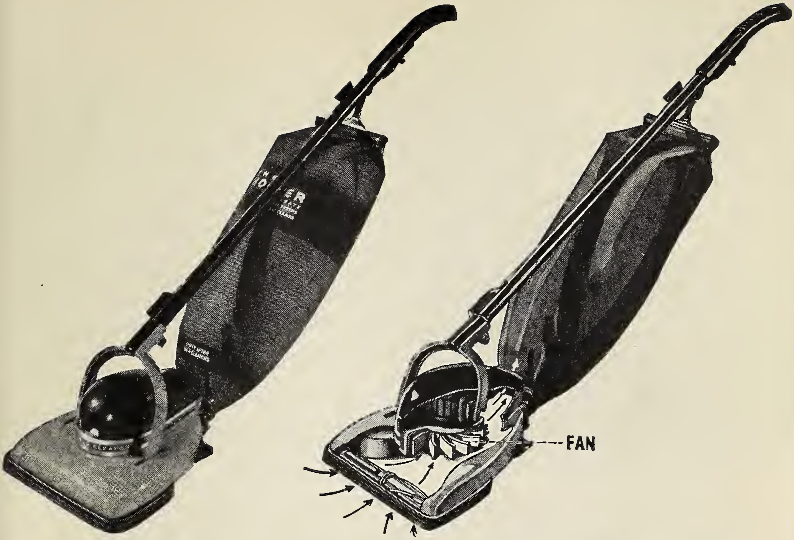
Tell about ways in which you have made use of the force of moving water.



How do we use the force of moving air?

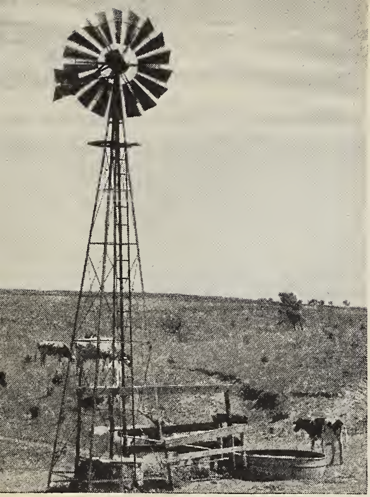
The force of the wind moved all of the things in this picture in less than three minutes! Do you see how the brick walls of the houses have been torn down? The force of the wind has ripped off the roofs and broken them into hundreds of pieces. It has carried parts of the houses more than a half mile away!

Sometimes terrible wind storms blow across dry fields, lift the fine bits of soil into the air, and make great dust-storms. The force of the moving air may carry thousands of car loads of soil for hundreds of miles before the dust settles to the earth again. Of course, a gentle wind does not have so much force. It may move the leaves of the trees, or it may blow dust into your house.



If this dust comes into your house, you may use a wind to clean it out again! Do you know how? An electric sweeper is a machine that works by using a strong wind. Here is a picture of the inside of an electric sweeper. Do you see the blades of the fan? Electricity turns the fan, and the fan makes a wind rush into the sweeper. If you put your hand across the opening of the sweeper, you can feel the pull of the wind as it rushes in.

When the sweeper is pushed across a dusty rug, the wind rushes in with so much force that it carries all the dust with it. The wind goes out through the bag of the sweeper, but the pieces of dust and dirt cannot get through. They collect in the bag.



You see, wind may bring dust into your house and may also be used to get it out again!

The picture on this page shows how the force of wind helps two boys. The boys must keep the tank filled with water, so that the cattle can drink. The boys always hope the wind will blow to turn the wheel and pump the water. Then they can play and let the wind work for them. If the wind stops blowing, they must stop their play and begin to use the force of their muscles to pump water into the tank. Men have used the force of wind to run windmills for hundreds of years.

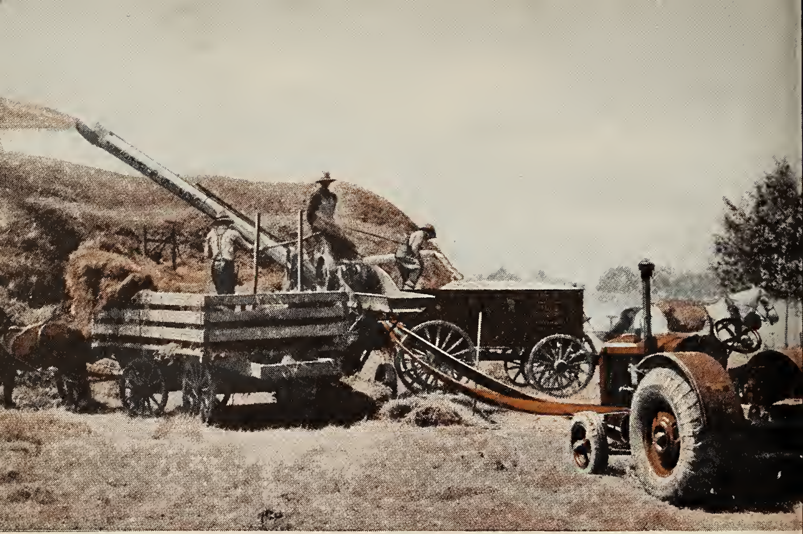
Perhaps the first way men used the force of wind was to make their boats move across the water. Long years ago, before men knew how to make engines, most boats were pushed by the wind. These boats had great sails on them. When the wind blew over the water, it pushed against the sails and moved the boats along. If the wind blew hard, the boats moved fast, but if the wind blew gently, the boats just drifted slowly along. The force of wind is also used to push boats over the ice. The wind sweeps over the frozen lake, pushes the sails, and sends the ice-boat slipping over the smooth ice at a great speed.

You may wish to make a sail-boat and take it to a pond and let the wind sail it. Another thing you can do is to make a pinwheel. If you fasten it on the window-sill or on the roof of your garage, the force of the wind will keep it turning much of the time.

Of course, we cannot make the wind blow to move things when we want them moved. Windmills and sail-boats have to wait for the wind to move them. But men have learned how to make air move with great force, so that it can help them in many ways.

You already know that we can make air move by using fans. The whirling fan in the electric sweeper blows the air that carries the dirt and dust from the carpet. And you have probably blown beans through a bean-shooter. Men use rushing air in the same way to move things through pipes. In factories fans blow air through big pipes. Cotton, wool, and other light materials are put in the pipes and moved from one part of the factory to another part by rushing air.

If you live on a farm, perhaps you have seen the blow-pipe of a threshing-machine. The thresher separates the wheat or oats from the straw. Then



a big fan rushes air through the blowpipe to blow the straw out on to a big pile. In the picture you can see the straw being blown out of the pipe.

* * *

In which of these ways is the force of wind like the force of water?

1. It is very strong.
2. It may be used to help us.
3. Sometimes it is harmful to us.
4. The faster it moves, the more force it has.
5. It can move very heavy things.

Would you rather take a long trip in a boat that is run by an engine, or in one that is moved by the wind? Why?

Why can steam move things?

Probably you have many times seen a long train of cars pulled by a puffing locomotive. You know that the locomotive is called a steam-engine. What force moves the engine and the long, heavy train of cars? It is the force of steam. Long after men learned to use the forces of wind and water, they discovered how to make steam move things. When they learned how to use this great force, they were able to do things that they had never done before.

Do you know where steam comes from? Probably you have watched a steaming tea-kettle. The steam comes from the water. Before the water can make steam, it must be heated. As the water in the kettle boils, it changes to steam. The steam

fills the kettle and then begins to come out of the spout. Sometimes you have seen the cover of the tea-kettle pop up and down. It is the force of the steam that makes the lid move.

An easy way to understand how steam can move things is to do this experiment. Fill a test-tube about half full of water. Put a cork in the top of the test-tube. *Do not push the cork in tightly.* Be careful to set it lightly into the opening of the test-tube. Now heat the test-tube gently over a flame. *Keep the cork pointed away from your face and away from anyone who is watching you.*

When the water gets hot enough, it changes into steam, and the steam quickly fills the test-tube. The water keeps on changing into steam. The steam crowds against the sides of the tube and also pushes against the cork.

At last there is so much push against the cork that it goes shooting off into the air. If the cork had been pushed tightly into the test-tube, the force of the steam would have burst the glass into hundreds of pieces.

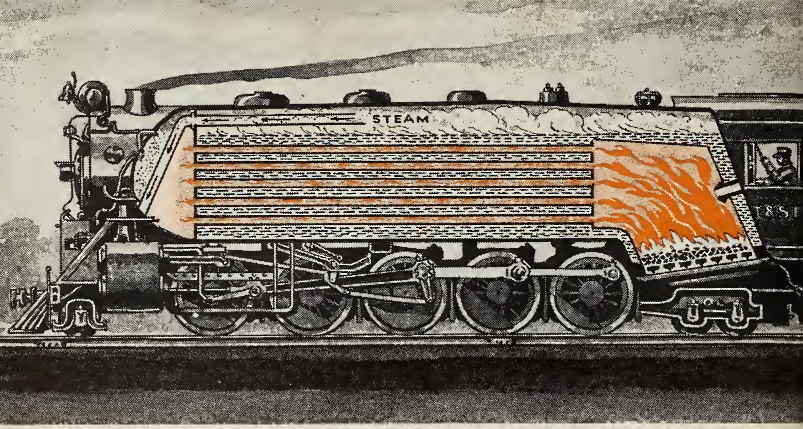
Now, why does the steam have such great force? When water changes into steam, it makes much steam out of a small amount of water. If one quart of water is all changed into steam, how many quarts of steam do you think it makes? It makes 1600 quarts!

It is easy to see that 1600 quarts of steam will push hard in all directions if you try to keep them all in the same space that a quart of water takes up. It is this push that gives the steam-engine its force. Every steam-engine has a boiler of water and a fire to change the water into steam. Pipes carry the steam to the engine.

The next time you see a locomotive pulling a long train of cars, you may say to yourself, "Steam gives the force that is pulling all of those cars. The coal is burning, and the heat from the burning coal is changing the water into steam. The steam is pushing hard to get out. It is this push that makes the wheels of the locomotive turn. The locomotive is just a machine for using the force of steam to move trains for us."

Steam-engines are also used to make ships move, to run big scoop shovels, and to run the machinery in factories.

Study the picture on the next page. It will help you understand how a locomotive is made. Do you see that almost all of the inside of the locomotive



is used to hold the water and the fire? There are two engines on a locomotive. There is one engine on each side of the locomotive near the front end. Can you find the pipe that carries the steam to the engines? These engines turn the wheels to make the locomotive move.

* * *

We need food so that we can move. What two things must a steam-engine have so that it can get steam to make it move?

What makes water turn into steam?

Is steam a solid or a liquid or a gas?

How do we use the force of explosions?

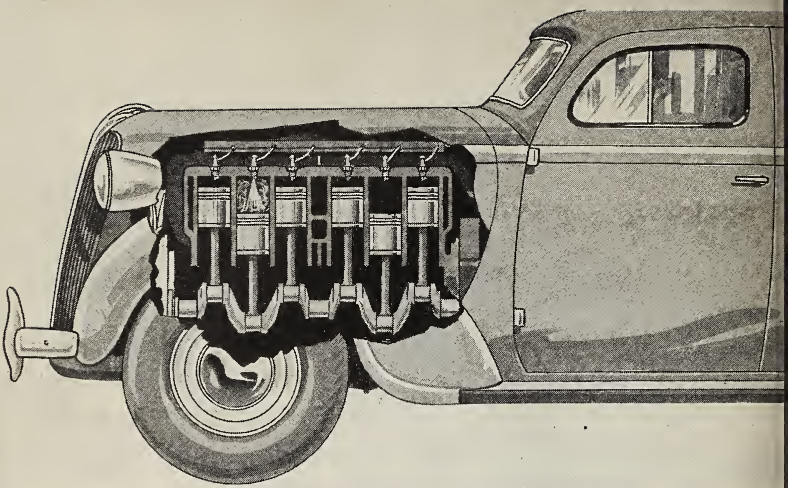
Did you ever travel on the force of an explosion? Perhaps you think that is a very funny question. But probably every boy and girl in your class has traveled on the force of explosions many times!

Whenever you ride in an automobile, you are being moved by the force of an explosion. The Bates car stopped moving because there was nothing in its engine to explode. Billy and his father had to walk along the hot, dusty road to get gasoline. It is gasoline that explodes inside the automobile engine and makes the engine move. Now let us see how the explosions happen.

We put gasoline into a tank at the back of the automobile. When it is put into the tank, it is a liquid. It flows through a long pipe to the top of the engine. Here it goes through a part of the engine that changes it into a fine spray. Air is mixed with the spray, and the gasoline changes into a gas. Then a tiny electric spark explodes the gas that has gone into the engine.

When gas explodes, it suddenly gets very much larger. It pushes out in every direction with a great force, in just the way that steam does. It is this great force that makes an automobile move. The gasoline explodes in the engine of the car. The force of the explosion moves parts of the engine. Then the wheels turn, and the automobile moves. An automobile is just a machine that is run by the great force of exploding gasoline.

This force can carry you over the roads at many miles an hour. It can also move great, heavy trucks and pull plows through the soil. It runs the engines



The inside of an automobile engine looks something like this. Do you see where the gasoline explodes?

that make airplanes fly swiftly through the skies. What a different world this would be if we did not have the force of exploding gasoline!

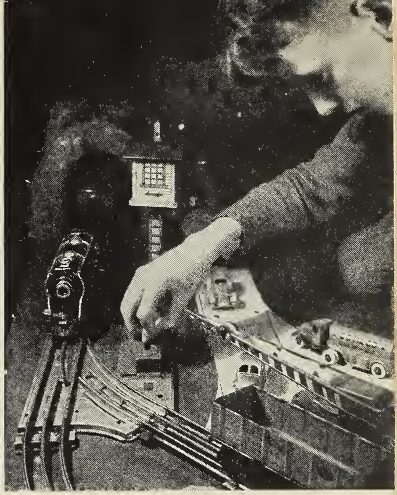
* * *

Tell what word is needed in each sentence.

1. Gasoline is a ...... when we put it in the tank.
2. Gasoline is a ...... when it explodes.
3. Gasoline has force when it explodes because it becomes a ....

How are steam and gasoline alike in the way in which they have force?

What makes gasoline explode?

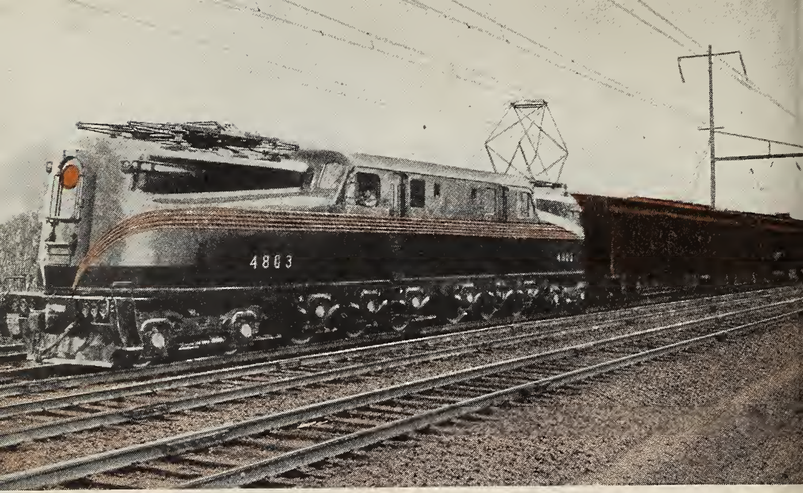


What can the force of electricity do?

Many things are moved by a force which no one has ever seen. No one has ever heard it, either. But people have felt it! It is the force that gives them a shock when they feel it. Perhaps you know now that we are thinking of the force of electricity. We have used the push and pull of electricity for many years, but scientists still do not know just what electricity is.

Here is a picture of a boy who is using the push and the pull of electricity. His father gave him an electric train for Christmas. It must have something to make it move. The boy has attached the train to an electric socket. The electricity can move the train very fast. When the boy wants to stop the train, he shuts off the electricity. Then the train will not move unless he pulls or pushes it with the force of his muscles.

We do not know just what electricity is, but we have learned how to make it and how to use it. Your mother may use the force of electricity to keep your clothes clean. She does if her washing



Electricity can move a whole train of cars.

machine is run by electricity. If her sewing-machine is an electric one, she uses the force of electricity to move the needle up and down when she sews.

If you live in the city, you may use the force of electricity to get from one place to another, for street-cars are moved by electricity. If you live in the country, you may use electricity to pump water for your cows and horses. Instead of waiting for the "push" of the wind to turn the windmill, you may use the "push" of electricity to run the pump.

You have learned that we boil water to get the force of steam. We make gasoline explode so that we can use the force of the explosion. Do you know how we get the force of electricity?

Men have invented a machine that makes electricity. This machine is run by the force of water or of steam or of exploding gasoline. Look at the picture on page 247. The water-wheel is running a machine that makes electricity. In your father's automobile is a little machine for making electricity. The electricity from this little machine makes the spark that explodes the gasoline.

The second way of making electricity is with an electric *cell.* The picture on the next page shows two of these electric cells. When we connect two or more cells to get more electricity, we say that we have an electric *battery.* There is a battery of cells in your automobile. The cells in this battery are different from the ones in the picture, but they give electrical force in the same way. When you push down on the starter of your automobile, the force of the electricity from the battery makes the automobile engine turn until the gasoline begins to explode and run the engine.

We have steam-engines so that we can use the force of steam, and gasoline engines so that we can use the force of exploding gasoline. Do you know what kind of machine we have so that we can use the force of electricity? We have electric *motors.* You probably have electric motors in your home. There is a motor in your electric sweeper, in your electric fan, and in your electric sewing-machine.

If you have a small electric motor, you can use

the force of electricity from a battery of cells to run the motor. In the picture do you see that the motor is connected to the battery of cells by wires? These wires carry the force of the electricity from the cells to the motor. Large electric motors are used to run street-cars. They are also used in factories to run all kinds of machinery.

* * *

Which of these sentences tell how the force of steam is like the force of electricity?

1. It is made by heating water.
2. It can move trains.
3. It has force because it gets bigger.

How do we use the force of springs?

You have learned about the four most important forces that we use to move things. But there is another force that helps us every day in little ways.

What force pulls your screen door shut after you have opened it? What force makes many kinds of toys move? What force makes a window-shade roll up? You have probably guessed that all of these things are moved by *springs.* We use the force of springs in many different ways to move things for us.

The piece of wire that makes the spring has no force in it. But when we wind it up into a coil and pull on it, it pulls back with great force. Men have learned to take a long, flat ribbon of steel and make it into a spring. When we wind this spring up, it can run clocks and watches and make toy engines pull trains on a track. If you could look inside an automobile engine, you would find many springs that help keep parts of the engine moving. Telephones and typewriters and doorbells and guns all need springs to make them work.

* * *

How have you used the force of springs in the last day or two?

The force of moving water is keeping Betty cool.

How can one force be changed to another?

Do you believe the sentence under the picture? Of course there is no moving water in the picture. Then how could Betty be using the force of moving water?

The electric fan is moving the air around Betty. It is moving her dress, the window curtain, and even her hair. This moving air is keeping her cool. Would you believe that Betty is being kept cool and that her dress is being moved by the force of moving water?

Betty has connected the electric fan to the wall socket in her room. This connects the fan with the wires that carry the electricity. The force of

If the water in the river stopped moving, Betty's fan would stop whirling.

electricity moves the fan, and the fan makes air move. Betty's home is a few miles from a river with a great power dam in it. The rushing waters of the river are used to run machines that make electricity. So the electricity is made because the force of moving water turns a water-wheel. Do you see how the force of moving water is changed into the force of electricity?

The force of electricity was changed into the force of moving air, and the moving air moved the things in Betty's room. The force of moving water is really helping the girl keep cool as she sits in front of the electric fan.

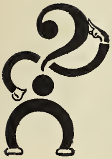
This kind of windmill runs a machine that makes electricity. You can see the machine just behind the blades of the windmill. The force of wind is changed to the force of electricity.

You very often use one kind of force to make another kind. Did you ever wind up a watch or a clock or a toy train? You used the force of your finger muscles to wind the spring. Then the force of the tight spring made the parts of the watch or clock or train move. Did you ever shoot with a bow and arrow? You used the force of your muscles to bend the bow. When you let go, the bow shot the arrow through the air.

* * *

How could explosions keep you cool?
How could a hot coal fire keep you cool?

Questions to Think About



1. (*a*) Which of these forces helps you most in your home: wind, electricity, steam?

b) What are the different ways in which this force helps you?

2. How are the forces of moving water, steam, electricity, and wind all alike?

3. (*a*) How does the force of gravity help us?

b) How does the force of gravity hinder us?

4. Which of all of the forces you have studied do you think helps us most? Why do you think so?

5. How do these men use the forces you have learned about? A dentist, a farmer, a railroad engineer, an automobile repair man.

6. Study the picture on page 252. How many kinds of forces can you see being used?

Things to Find Out

1. Visit a place where water is being used to make electricity. Find out where the water-wheel is.

2. Find out how many kinds of forces your father uses to do his work.

3. Find out what force is used to make the electricity in your home or town.

4. Bring a toy steam-engine to school. Run the engine so that the class can see that steam has power.

5. Write a story that tells how the world would be different if there were no forces of electricity, steam, gasoline, or wind.

6. Find out how men move things by exploding other materials besides gasoline. For example, how are big blocks of stone broken loose in stone quarries? What makes a bullet move from a gun?

7. If you can do so, make a visit to a steam locomotive and find out all you can about how the force of the steam is used.

SCIENCE WORDS

Can you say the word "Chrysalis"? Do you know what it means? You can tell by finding it in the list below. This list shows you how to say, or *pronounce*, the science words in your book.

Notice that the words are written twice. The second time there are little marks over or under some of the letters. The marks show you how each letter sounds. If the letter "a" has a mark like this "ā," it sounds like the "a" in the word "came" or the word "face." Study the following sounds, and you will understand what the marks mean.

a	at, can	ē	be, me	ō	open, broke
ā	came, face	ė	her, longer	o̤	connect, second
ä	far, farther	e̤	towel, quiet	ö	moon, move
â	all, ball	i	pin, it	u	up, but
a̤	alone, company	ī	mine, line	ū	use, pure
e	end, bend	o	rock, not		

a lu mi num (a-lū′mi-num), a silver-white metal.

am phib i an (am-fib′i-a̤n), an animal, such as the frog, that lives part of its life on land and part of its life in water.

a qua ri um (a̤-kwa′ri-um), a tank or glass bowl where fish, other water animals, and water plants are kept.

ax is (ak′sis), a real or imaginary straight line around which a thing turns.

Bet el geuse (bet′e̤l-jūz), a large star in the constellation Orion.

bud, the beginning of a flower, leaf, or branch.

car bon di ox ide (kär′bo̤n dī-ok′sīd), a gas that cannot be seen or smelled and is made of carbon and oxygen.

Cassiopeia (kas-i-ō-pē′ya̤), a group of stars in the northern sky.

Cecropia (sē-krō′pi-a̤), the name of a large moth.

cell (sel), part of an electric battery.

chrysalis (kris′a̤-lis), the part of the life of a butterfly when it is in a case.

cobalt (kō′bâlt), a silver-white metal.

cocoon (ko̤-kön′), a silky covering made by caterpillars to live in while they are turning into moths.

cone (kōn), the part of some kinds of plants that holds the seeds. Pine trees have cones.

constellation (kon-ste-lā′sho̤n), a group of stars.

decay (dē-kā′), to rot. Teeth may decay or rot if they are not cared for.

dissolve (di-zolv′), to change into a liquid by mixing with a liquid. Sugar dissolves in water.

engineer (en-ji-nēr′), a man who makes, or takes care of, or runs engines; a man who plans or builds machines, roads, or bridges.

evaporate (ē-vap′ō-rāt), to change into a gas.

experiment (eks-per′i-ment), to try to find out something; a test to find out something.

explosion (eks-plō′zho̤n), blowing up; a sudden pushing out in all directions, often caused by lighting a gas.

fact, a thing that is true. It is a fact that ice melts.

fertilizer (fėr′ti-lī-zėr), a material that is mixed with the soil to help plants grow.

flamingo (fla̤-ming′gō), a long-legged water-bird that lives in hot countries.

flower (flou′ėr), the part of a plant that grows the seeds.

fog, a cloud of very fine drops of water that stays near the surface of land or a body of water.

fruit, the part of a plant where the seeds are.

geranium (je̤-rā′ni-um), a plant with white, pink, or red flowers.

gill (gil), a part of the body of an animal that is used for breathing in water.

grain, the seed of plants like corn, wheat, and oats. *Grain* also means a tiny bit of material, as, a grain of salt or sugar.

gravity (grav′i-ti), the force that pulls all things toward the earth.

heavenly (hev′n-li), having to do with the sky. The sun, moon, and stars are heavenly bodies.

hemlock (hem′lok), a kind of tree that grows its seeds in cones.

human (hū′ma̤n), having to do with people. Men, women, and children are human beings.

insect (in′sekt), a small animal with six legs and a body divided into three parts.

intestine (in-tes′tin), a long tube into which the food from the stomach goes.

Jupiter (jö′pi-tėr), the largest of the nine known planets; also, king of the gods in old-time stories.

locomotive (lō-kō-mō′tiv), a railroad engine.

lodestone (lōd′stōn), a kind of rock with much iron in it that attracts iron and steel.

Magnes (mag′nēz), the name of a shepherd who is said to have first found lodestone.

magnifying-glass (mag′ni-fī-ing-glas), a glass that makes things look larger.

mammal (mam′a̤l), the name of a group of animals. Mammals feed their babies milk from their own bodies.

marionette (mar′i-o̤-net′), a small doll moved by strings.

Mars (märz), the planet nearest the earth.

Mercury (mėr′kū-ri), the planet nearest the sun.

metal (met′a̤l), a material such as iron, gold, silver, copper, lead, and nickel.

meteor (mē′tē-o̤r), a solid object made of rock or metals or a mixture of rock and metals that falls through the sky; sometimes called a "shooting star."

meteorite (mē′tē-o̤r-īt), a piece of a meteor that has fallen to the earth.

microscope (mī′krọ̄-skōp), an instrument that makes very small things look larger so that we can study them better.

molt (mōlt), to shed skin or feathers.

narcissus (när-sis′us), a white or yellow spring flower that grows from a bulb.

Neptune (nep′tūn), the name of a planet.

nerves (nėrvz), white thread-like parts of the body that carry messages to and from all parts of the body.

nickel (nik′e̤l), a metal that looks like silver.

non-living (non-liv′ing), something that is not alive and never was alive.

Orion (ō-rī′o̤n), a group of bright stars in the southern sky.

oxygen (ok′si-jen), a gas that makes up part of the air. It cannot be seen or smelled.

palm (päm), the inside of the hand.

perspiration (pėr-spi-rā′sho̤n), sweat. Sweat is a liquid made of materials that the body does not need.

petal (pet′a̤l), one of the parts of a flower.

petunia (pē-tū′ni-a̤), a common garden plant with white, pink, or purple flowers.

planet (plan′et), a heavenly body that moves around the sun.

Pluto (plö′tō), the name of the planet farthest from the sun.

pod, the shell or case in which plants like peas and beans grow their seeds.

polar (pō′la̤r), near the North or the South Pole.

Polaris (pō-la′ris), a name for the North Star, or the Pole Star.

pole, either end of the earth's axis. *Pole* also means one of the two places in a magnet where the force is strongest.

reptile (rep′til or rep′tīl), a cold-blooded animal with scales, and lungs for breathing.

Rigel (rī′je̤l), a large, bright star in the constellation Orion.

salamander (sal′a̤-man-dėr), an animal shaped like a lizard. It belongs to the same group of animals (amphibians) as frogs and toads.

saliva (sa̤-lī′va̤), the liquid in the mouth that helps to dissolve food.

sap, the watery liquid that travels through a plant and carries food.

Saturn (sat′ėrn), the planet that has rings around it.

scientist (sī′e̤n-tist), a person who spends his life studying science and discovering things about the world.

seed, the part of a plant that will grow into a new plant.

shoot (shöt), a new part growing from a plant.

shrub, a woody plant smaller than a tree, with many separate stems starting near the ground. *Shrub* is another word for bush.

skeleton (skel′e̤-to̤n), the bony framework of the body; in insects, the hard outside covering.

skull, the rounded, bony covering that protects the brain.

sleet, half-frozen rain.

spinal cord (spī′na̤l kord), a long, white cord that runs down through the center of the backbone.

spine (spīn), the backbone, or long row of bones up the back of the body.

spruce (sprös), a kind of tree that grows its seeds in cones.

stalk (stâk), the stem of a plant.

struc ture (struk′chėr), the parts of anything and the way in which the parts are put together.

tad pole (tad′pōl), the early part of the life of a frog or a toad.

tel e scope (tel′e-skōp), an instrument for making things that are far away look nearer.

tem per a ture (tem′pėr-a̤-chėr), how hot a thing is.

ther mom e ter (thėr-mom′e-tėr), an instrument for measuring how hot any thing is.

tin, a metal that shines like silver. It melts very easily and is often used to make a coating over other metals.

U ra nus (ū′ra̤-nus), the name of a planet.

Ur sa Ma jor (ėr′sa̤ mā′jo̤r), Great Bear, the name of a group of stars.

Ur sa Mi nor (ėr-sa̤ mī′no̤r), Little Bear, the name of a group of stars.

va por (vā′po̤r), a gas made from a liquid or solid, such as water vapor.

veg e ta ble (vej′e-ta̤-bl), a plant that is used for food, as peas, corn, lettuce.

vein (vān), a kind of tube that carries blood through the body.

Ve nus (vē′nus), the brightest planet.

wind pipe (wind′pīp), the tube that carries air to and from the lungs.

INDEX

In the next few pages is a list of things that your book tells about. This list is called an *index.* You can use the index to find things in your book.

Notice that all the words beginning with "A" come first. All words that begin with "B" come next. Find the words that begin with "S."

Suppose that you want to find out what kind of animal a cat is. First, look for "cat" in the index. What pages in your book tell about cats? Look at page 15 and find out what it tells you about cats. What does page 21 tell you? Does page 22 tell you what kind of animal a cat is?

Does glass belong to the group of living things or to the group of non-living things? Find the pages in your book that tell you.

A star after a number (like 33*) means that there is a picture on that page. What page has a picture of a cat? What pages have pictures of frogs?

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TEACHER'S NOTES*

This book is written as an aid to the teacher in her efforts to teach purposeful science to boys and girls. The content has been selected because it is interesting, because it is within the environment of most elementary pupils, and because it lends itself to accomplishing important objectives in child growth and development.

The teacher should keep in mind that the purpose of science instruction is to stimulate and direct the interest of the child in his environment, to help him see relationships between facts, to aid him to arrive at major principles and generalizations based on the facts, to foster and promote a scientific method of solving problems, and to develop in him a scientific attitude toward himself and his environment.

The necessity of developing a scientific way of thinking is of vital importance. Every available opportunity should be used to help pupils to become more observing, to look at a problem from every side before they express an opinion, to experiment carefully and accurately, to demand reliable sources of information, to withhold judgment until there is sufficient evidence to permit the drawing of conclusions, and to react intelligently to superstitious beliefs.

Throughout the book situations have been included to help the teacher in the development of such attitudes. For example, in Unit 1 see: *Page 12.* Description of how children may find the answers to questions. *Page 20.* Lines that tell how a scientist attacks a problem. *Page 28.* Lines that indicate that children must look at more than one reptile before they draw conclusions about *all* reptiles. *Page 31.* Lines that tell how children observe *carefully* to find answers to questions. *Pages 33-34.* Lines that indicate methods of thorough investigation before drawing conclusions. *Page 46.* Questions 1 and 2.

Needless to say, the ideal situation is one in which the teacher enlists the active coöperation of her class members in planning and executing the activities involved in these science units. The teacher will doubtless think of many ways of achieving this ideal situation, but the following suggestions may be of help.

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*Detailed, page-by-page suggestions for teaching the material of the book are given in the Teacher's Manual furnished free by the publishers.

1. Interest pupils in an active program of observing and collecting as much material as possible from their surroundings.

2. Encourage boys and girls to suggest additional experiments, excursions, and sources of observations.

3. Plan the course with the boys and girls as the work proceeds.

The attitude of the teacher must necessarily be: I may sometimes need to say to pupils, "I do not know the answer, but I shall be glad to help you to find out." With such an attitude, the class and the teacher may solve coöperatively problems of mutual interest. A spirit of working together, diligently and accurately, is most highly to be desired. The conclusions then seem doubly important, for the method of solving is no less important than the results obtained.

Stimulate the pupils to do as much observing as possible. Let them examine plants and animals and arrive at their conclusions, much as the boys and girls in Unit 1 did. Try always to draw on their previous experience and on their observations made outside of the classroom.

It is suggested that at the beginning of each unit the *teacher and pupils* look through the unit and decide where they can get the materials needed. The lists given in these notes will aid the teacher to guide the pupils as they make their survey. Suggest to the pupils that they take the responsibility for obtaining the material whenever possible.

UNIT 1. HOW THINGS ARE CLASSIFIED

Purpose of Unit 1. It is suggested that the teacher and pupils try to carry out a plan similar in nature to that pursued by the teacher and the pupils in this unit. A modification of the shelf idea might well be a science table where pupils can bring their materials and label them according to their classification.

The emphasis in this unit is not alone on teaching the classification of animals and plants. It is important that the pupil understand the meaning of the term *structure*, and that he fully comprehend the value of a knowledge of structure as an aid to classifying and studying plants and animals. The idea that living things have parts and that these parts are different in different species is fundamental. It is probably a new idea to children that things are grouped according to structure.

The pupils should further understand that only through *careful study* and *observation* of plants and animals, have scientists been able to divide these living things into groups. They should realize that scientists do not generalize without sufficient evidence. That is, they study thoroughly a number of animals or plants before they decide into which group a given specimen belongs.

Materials Needed for Experiments and Activities in Unit 1. The materials needed to enrich the teaching of Unit 1 may be collected by the pupils themselves, as suggested by the procedure described in the unit. Usually it is not wise to keep live animals in the classroom for too long a period, especially since most classrooms are not equipped with the necessary cages, etc., to keep such animals comfortably. Pictures may be substituted for the kinds of animals not available for actual observation. Pictures collected from year to year may be filed for use as future visual aids.

The children may construct cages for the animals. An aquarium stocked with fish and water plants is helpful. Often pupils may bring fish bowls from home, or small aquaria may be purchased at local stores. Magnifying-glasses are also valuable aids. Children are often able to bring reading glasses from home.

The plant material should include flowering plants in the classroom, a bean plant from a garden, a fern (with spores, if possible), different kinds of moss gathered from the woods, mushrooms, toadstools, and pine cones.

UNIT 2. GROWTH

Purpose of Unit 2. The important objectives are: To teach that growth, in addition to involving increase in size, is usually characterized by changes in structure. To teach that food is essential to growth. To teach that growth is a self activity of the organism in that the organism takes in materials from the outside and changes them into the materials of which the organism is made. To help the pupils accurately to observe growing things and to make note of their observations.

Many of the situations described in this unit may easily be duplicated in the classroom. It is essential that much of the material of the unit be learned through actual observation of live plants and animals.

Materials Needed for Experiments and Activities in Unit 2. Live material should include larvae of different kinds, cocoons, tadpoles of various ages, bean and corn seeds planted as suggested on page 65, twigs and branches that show growth, pieces of wood sawed as shown on page 73, a corn-stalk, white rats for the experiment on page 79, and house plants from which cuttings may be made (page 82).

The children can probably bring scales to use in weighing the rats, and can make cages for the animals. They can also bring magnifying-glasses to use in examining roots, seeds, stems, and the inside of a corn-stalk.

UNIT 3. AIR AND WATER

Purpose of Unit 3. It is not the purpose of Unit 3 to teach all the facts about air and water. The function of the unit is, rather, that of showing how these materials are essential to the maintenance of life. Such facts about air and water are introduced as are necessary to an understanding of the function of these materials in supporting life.

The material in this unit extends and illuminates much of the discussion in Unit 2, and is prerequisite to the understanding of much of Unit 4. It would be well for the teacher to read Unit 4 before teaching Unit 3 in order that she may see how the two units interlock.

Try to apply the science learned here to the care of animals and plants in the classroom; that is, animals in the classroom must have plenty of fresh air and water, plants cannot live without water, insects kept in glass jars must be supplied with air, etc. Stress the fact that scientists have done much experimenting and studying to find out what plants and animals need so that they can live and grow.

Materials Needed for Experiments and Activities in Unit 3. Page 87. Drinking glass, cork, pan, water. *Page 88.* Paper bag. *Page 90.* Cloth, electric light, pan of water, heat. *Page 91.* Lump of soil, glass of water. *Page 95.* Geranium leaf, microscope (if possible), vaseline or lard, growing plant. *Page 98.* Map of the world or globe of the world. *Page 99.* Glass jar. *Page 100.* Tin cup, chopped ice. *Page 102.* Lump of sugar, cloth, glass of water. *Page 103.* Glass jar, red ink, celery, 2 pieces of cloth, bean seeds. *Page 107.* Glass bottle, dandelion plant, corn seeds, green leaves, fruit, microscope (if possible).

UNIT 4. THE HUMAN MACHINE

Purpose of Unit 4. The major objective of this unit is to lay a basis for an intelligent, coöperative attitude on the part of the pupil toward the various community and school activities devoted to his health. Needless to say, such an attitude, if developed, is reflected in the pupil's greater attention toward his own physical well-being.

Note that the approach is through function. Structure is not presented as an end in itself; it is presented as essential to the understanding of why the human body can do what it does and how it may be kept in good working order. Thus the material of the unit furnishes the scientific background for the health courses frequently taught in the grades. If there are no health classes, this unit may well serve as a basis for such instruction.

Try to have your school nurse or physician come to your classroom and test the hearing and sight of the pupils while you are studying these pages. Let the physician or nurse know about the work you are doing so that they may add to the value of the unit by making additional comments.

Material Needed for Experiments and Activities in Unit 4. Material of the nature listed here, while not essential to the teaching of the unit, will be of great help to the pupils in understanding the unit. *Page 115.* Different kinds of bones (see text). *Page 118.* Animal skull (if possible). *Page 120.* Joint from a cow or pig obtained at the meat-market. *Page 132.* Magnifying-glass. *Page 139.* Piece of meat showing nerve. *Page 142.* Bone from meat-market.

UNIT 5. DAYS AND NIGHTS

Purpose of Unit 5. Units 5 and 6 introduce the pupil to the study of the solar system and the universe. Needless to say, at this grade level the subject can be presented only in broadest outlines. Much of it can go no further than to focus the pupil's attention on the various phenomena, and to show him something of the sequence, significance, and orderliness of what he sees. Abstruse cause and effect relationships are not, and cannot be, presented at this grade level.

Thus, Unit 5 has for its central theme the most obvious effect of the earth's movements, namely, alternate periods of darkness and light. It is important to help the pupils understand and see the relationship between the ideas of: (1) shape of the earth, (2) source of the earth's light, (3) movements of the earth, and (4) cause of day and night.

It is not the purpose of this unit to teach the cause of the seasons, but merely to help pupils to begin to see the effects of the sun's light on the earth at various times of the day and year. The pupils should become conscious of the fact that during the year we have long days and short days because the earth moves the way it does.

Another, and no less important, outcome to be desired is an understanding of the method of discovery used by scientists through the ages, that is, the method of careful observation and experimentation and of accurate thinking.

The unit establishes a foundation for understanding some of the principles used in Unit 6.

Materials Needed for the Experiments and Activities in Unit 5. Page 146. Electric light with clear glass. *Page 152.* Small boat, globe, soft clay, table. *Page 154.* Globe, top. *Page 155.* Orange, stiff wire, a quarter or a half dollar. *Page 157.* Globe, flashlight, chalk. *Page 166.* Newspaper, almanac. *Page 168.* Yardstick, light. *Page 171.* Yardstick, pin, sheet of paper, pencil.

UNIT 6. HEAVENLY BODIES

Purpose of Unit 6. As a result of the study of this unit, pupils should become more observing of, and interested in, the heavens. Constellations, the moon, "shooting stars," and other heavenly bodies should take on added meaning. Something of the vastness of the universe should begin to be impressed upon them.

From this unit as well as from previous units, pupils should come to appreciate the careful study by means of which scientists have gained information concerning the heavenly bodies. It is important to stress the fact that there is still much to be discovered and that scientists are acquiring new information each year.

The pupils may become interested in reading myths and in listening to radio programs that involve astronomy and fanciful stories of the heavenly bodies. The desire and the ability to discriminate between fact and fancy should be an outcome of the study of the unit.

Materials Needed for Experiments and Activities in Unit 6. Page 175. Knitting needle or piece of iron wire, source of heat, pliers. *Page 186.* Black umbrella, globe, crayon or chalk, cardboard and paste. *Page 192.* Flashlight or candle, globe, calendar showing moon phases if possible. *Page 193.* Ball, black and white paint.

UNIT 7. MAGNETS

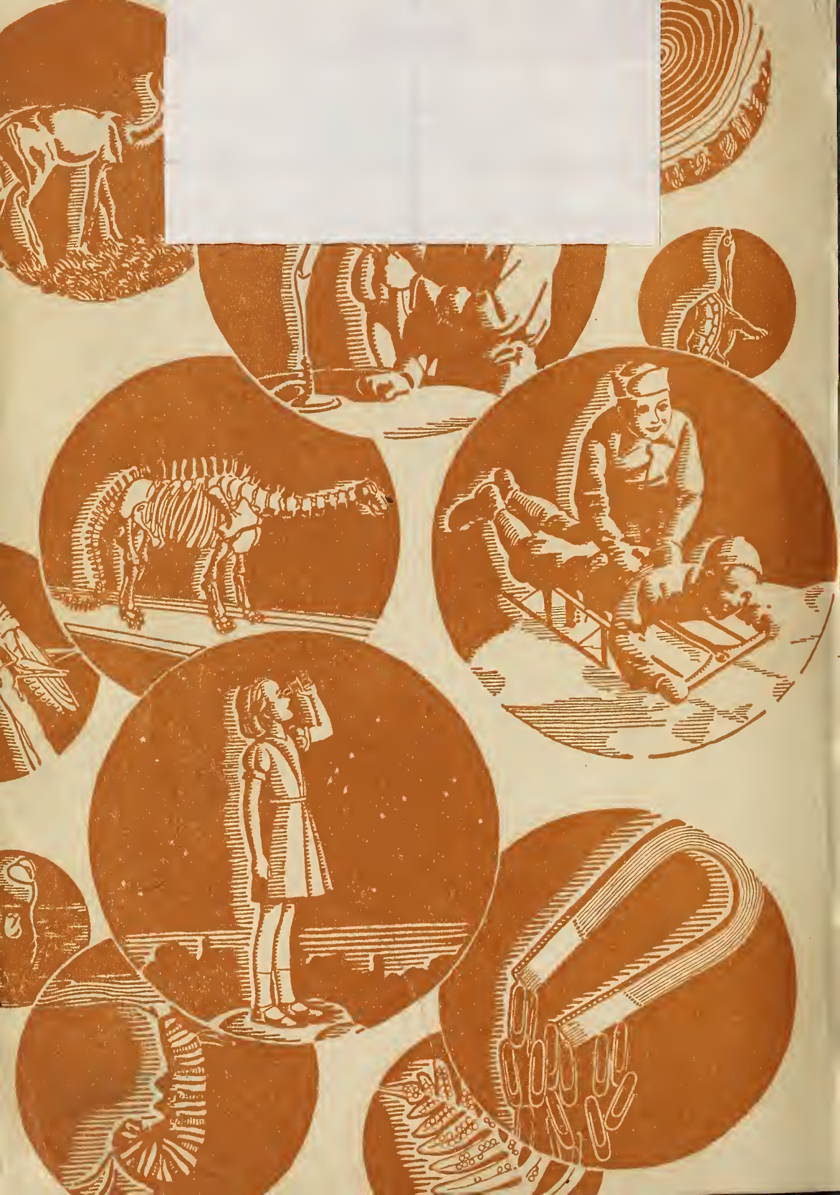
Purpose of Unit 7. In addition to learning interesting facts about the force of magnetism another very important purpose of this unit is training in accurate experimentation. The unit affords much opportunity for experimenting. Encourage pupils to suggest experiments of their own in addition to those given in the text. Stress the necessity of experimenting carefully and accurately and the importance of drawing conclusions only when there is sufficient evidence to justify such conclusions. It is suggested that the teacher leave the materials used in the unit out on a table so that the pupils may use them during out-of-class time.

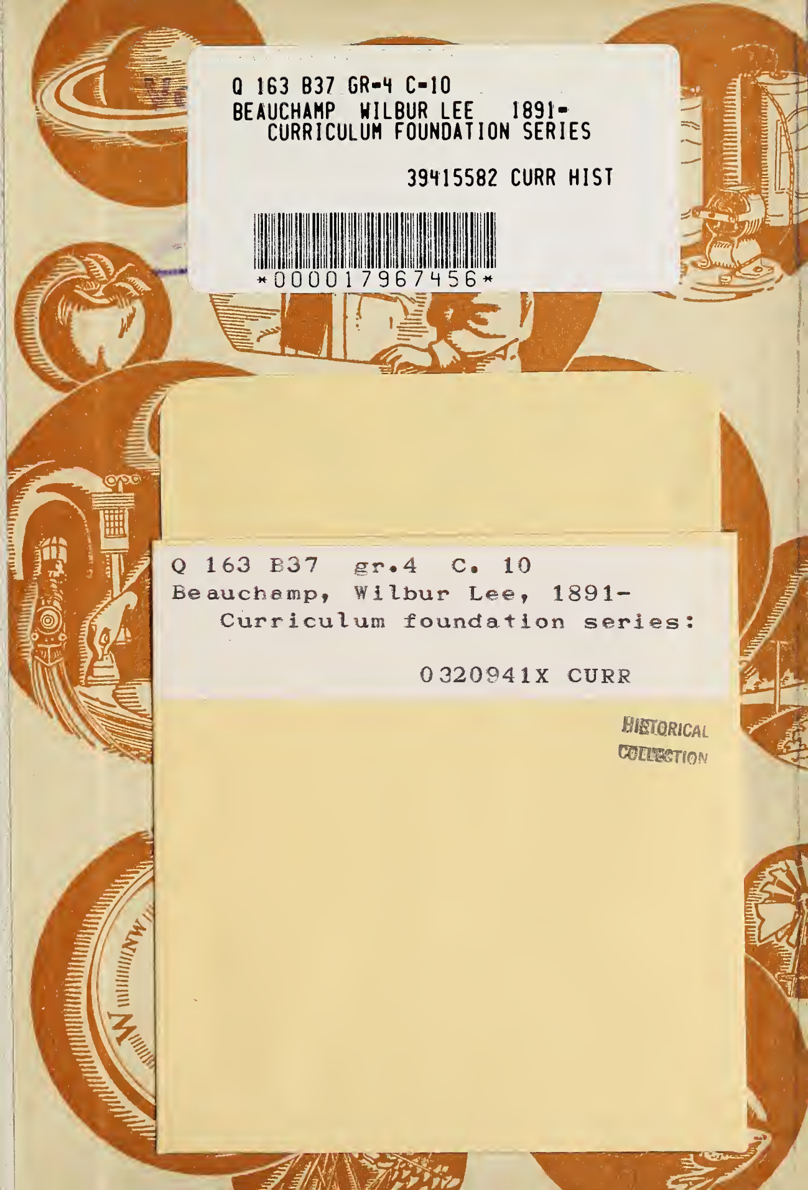
Materials Needed for the Experiments and Activities in Unit 7. Page 205. Compass. *Page 206.* Bar, horseshoe, and U-shaped magnets. *Page 207.* Piece of lodestone, if possible. *Page 208.* Miscellaneous materials as listed, magnet. *Page 209.* Tin cup, magnet, materials listed in question 2, piece of glass, nails, books. *Page 210.* Piece of thin wood, paper, cloth, painted iron. *Page 211.* Thumb tacks, horseshoe magnet. bar magnet, box, iron filings. *Page 212.* Bar magnet, wooden frame, wire, string. *Page 213.* Magnets, iron nail. *Page 214.* Cardboard, iron filings, magnets, tacks, thread, saltshaker. *Page 216.* Two bar magnets, wooden frame, string. *Page 218.* Two bar magnets, two horseshoe magnets, magnet with poles not marked. *Page 220.* Wooden boat, two bar magnets, pan of water. *Page 223.* Compass. *Page 226.* Magnet, a needle, flat piece of cork, dish of water, *Page 230.* Piece of leather, jack knife, a nail, iron filings, sand, magnets of varying strength, iron ring, piece of sheet iron or steel. *Page 231.* Cardboard box, figures of cardboard, paper clips, strong magnets, compass.

UNIT 8. FORCES

Purpose of Unit 8. This unit is not to be considered a unit on machines. It is, rather, a broad overview of the forces that make machines go. It constitutes an introduction for a later study of the general subject of force, energy, and work. The concept of energy is touched upon, but the word energy is not used. The unit is confined to the simple, observable phenomena of forces, the understanding of which lays a foundation for the later, more detailed discussion of energy and work. The unit is written in answer to the question often asked, "What makes it go?"

Materials Needed for the Experiments and Activities in Unit 8. Page 244. Saw, hammer, nails, pieces of board, running water. *Page 245.* Spool, toy churn or other toy with wheel for attaching. *Page 254.* Test-tube, cork, test-tube holder, heat, water. *Page 262.* Two dry cells, copper wire, electric motor. *Page 267.* Toy steam-engine.





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